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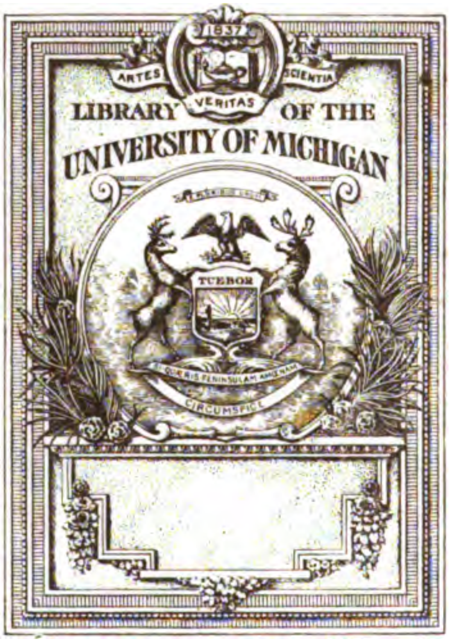

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SUPPLEMENT

TO THE THIRD EDITION OF THE

ENCYCLOPÆDIA BRITANNICA,

OR, A

DICTIONARY

OF

ARTS, SCIENCES,

AND

MISCELLANEOUS LITERATURE.

IN TWO VOLUMES.

Illustrated with Fifty Copperplates.

BY GEORGE GLEIG, LL. D. F. R. S. EDIN.

NON IGNORO, QUÆ BONA SINT, FIERI MELIORA POSSE DOCTRINA, ET QUÆ NON OPTIMA,
ALIQUO MODO ACUI TAMEN, ET CORRIGI POSSE.—*CICERO.*

VOL. II.

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ADVERTISEMENT.

It would ill become me to diſmiſs theſe Volumes from my hands without acknowledging that, from many of the moſt valuable diſquiſitions which they contain, I can claim no other merit than that of having uſhered them into the world.

Those who have read, and who underſtand, the articles in the Encyclopædia Britannica, which were furniſhed by Profeſſor Robiſon of Edinburgh, can hardly need to be informed, that to the ſame eminent philoſopher I am indebted for the valuable articles Arch, Astronomy, Carpentry, Centre, Dynamics, Electricity, Impulsion, Involution *and* Evolution *of Curves*, Machinery, Magnetism, Mechanics, Percussion, Piano-*Forte*, *Centre of* Position, Tempérament *in Muſic*, Thunder, *Muſical* Trumpet, Tschirnhaus, and Watchwork, in this Supplement. Of a friend and co-adjutor, whoſe reputation is ſo well eſtabliſhed as Dr Robiſon's, I am proud to ſay, that, while I looked up to him, during the progreſs of this Work, as to my maſter in mathematical and phyſical ſcience, I found him ever ready to ſupport, with all his abilities, thoſe great principles of religion, morality, and ſocial order, which I felt it my own duty to maintain.

To Thomas Thomſon, M. D. of Edinburgh, a man of like principles, I am indebted for the beautiful articles Chemistry, Mineralogy, and *Vegetable*, *Animal*, and *Dyeing* Substances; of which it is needleſs for me to ſay any thing, ſince the Public ſeems to be fully ſatisfied that they prove their author eminently qualified to teach the ſcience of chemiſtry.

The account of the French Revolution, and of the wars which it has occaſioned, has been continued in this Supplement by the ſame Gentlemen by whom that account was begun in the Encyclopædia; and, owing to the cauſe aſſigned in the article, probably with the ſame merits and the ſame defects.

My thanks are due to Dr William Wright for his continued kindneſs in communicating much curious botanical information: and to Mr Profeſſor Playfair of the univerſity of Edinburgh, for lending his aſſiſtance, occaſionally, in the mathematical department; and for writing one beautiful article in that ſcience, which is noticed as his in the order of the alphabet.

In compiling this Supplement, I have made very liberal uſe of the moſt reſpectable literary and ſcientific journals, both foreign and domeſtic; of all the late accounts of travels and voyages of diſcovery, which have obtained, or ſeem indeed to deſerve, the regard of the Public; of different and oppoſite works on the French revolution, and what are emphatically called *French principles;* and even of the moſt approved Dictionaries, ſcientific and biographical. From no Dictionary, however, have I taken, without acknowledgment, any articles, except ſuch as are floating everywhere on the ſurface of ſcience, and are the property, therefore, of no living author.

After all my labour and induſtry, which, whatever be thought of my other merits, I am conſcious have been great, no man can be more ſenſible than myſelf, that the Encyclopædia Britannica, even with the addition of this Supplement, is ſtill imperfect. It would continue to be ſo, were another Supplement added to this by the moſt learned and laborious man on earth; for perfection ſeems to be incompatible with the nature of works conſtructed on ſuch a plan, and embracing ſuch a variety of ſubjects.

No candid reader will ſuppoſe that, by expreſſing myſelf thus, I mean to cenſure the plan of the Encyclopædia Britannica in particular; for, to the general excellence of that plan I have elſewhere borne my teſtimony, which I have yet ſeen no reaſon to retract. Experience has indeed led me to think, that it is ſuſceptible of ſuch improvements as would enable the principal Editor to carry the work *nearer* to perfection, even with leſs trouble to himſelf; but the purchaſers of the third edition and this Supplement need not regret the want of thoſe improvements, for they are ſuch as few would diſcern, who have not paid the ſame attention that I have done to dictionaries of arts, ſciences, and literature.

Before I take leave of the reader, I muſt account for the omiſſion of one or two articles (chiefly biographical) which I had given him reaſon to expect in theſe volumes. It was my intention at firſt to introduce into the Supplement articles on every ſubject which had been admitted into the Encyclopædia itſelf; and hence in the firſt ſupplementary volume will be found biographical ſketches of men whoſe characters, though in ſome reſpects remarkable, have very little connection with ſcience, arts, or literature. From this part of the original plan I was ſoon obliged to deviate. So many applications were made to me to inſert accounts of perſons who, whatever may have been their private virtues, were never heard of in the republic of letters, that I was under the neceſſity of excluding from the ſecond volume the lives of *all* ſuch as had not either been themſelves eminent in literature, or in ſome liberal art or ſcience, or been conſpicuous as the *patrons* of ſcience, arts, and literature, in others. Hence the omiſſion of the life referred to from Aubigne in the firſt volume, and of one or two others to which references are made in the ſame way. The life of Mr James Hay Beattie of Aberdeen, whoſe originality of genius, ardent love of virtue, and early and extenſive attainments in ſcience and literature, raiſe him almoſt to the eminence of Barretier, of whom we have ſo pathetic an account from the pen of Johnſon, I omitted with regret; but I thought not myſelf authorized to publiſh what his father had then only diſtributed among a few particular friends. For the omiſſion of the life of Soame Jenyns I can make no apology: it was the conſequence of forgetfulneſs.

For the *errors* of theſe two volumes, whether typographical or of a nature more important, I have perhaps no occaſion to ſolicit greater indulgence than will be voluntarily extended to me by a generous public. The progreſs, however, of ſcience, and of the revolutionary events in Europe, has been ſuch, ſince great part of them was printed, that I muſt requeſt the reader, in juſtice to myſelf, to proceed directly from the article Galvanism to Torpedo, and from Revolution to the life of Marſhal Suworow.

Under the title Translation, both in the Encyclopædia and in the Supplement, expreſſions are made uſe of, which may lead the reader to ſuppoſe that Mr Fraſer Tytler was indebted for the general laws of the art, which he ſo ably illuſtrates, to Dr Campbell's Preliminary Diſſertations to his Tranſlation of the Goſpels. It is but juſtice to declare my perfect conviction, as it was that of Dr Campbell himſelf, that Mr Tytler and he were equally intitled to the merit of having diſcovered thoſe laws; and that however coincident in opinion, neither of them, when compoſing their ſeparate works, had the ſmalleſt ſuſpicion that the other had ever employed his thoughts on the ſubject. The only difference ſeems to have been in the mode of their diſcovery: Mr Tytler having deduced the laws of the art by regular analytical inference from his own deſcription of a perfect tranſlation; whereas Dr Campbell appears to have fortunately diſcovered them without that proceſs of deduction.

SUPPLEMENT

TO THE

ENCYCLOPÆDIA BRITANNICA.

Increment, Indeterminate.

INCREMENT, is the ſmall increaſe of a variable quantity. Newton, in his Treatiſe on Fluxions, calls theſe by the name *Moments;* and obſerves, that they are proportional to the velocity or rate of increaſe of the flowing or variable quantities in an indefinitely ſmall time. He denotes them by ſubjoining a cypher o to the flowing quantity whoſe moment or increment it is; thus, xo the moment of x. In the doctrine of Increments, by Dr Brooke Taylor and Mr Emerſon, they are denoted by points below the variable quantities; as $\underset{.}{x}$. Some have alſo denoted them by accents underneath the letter, as $\underset{\prime}{x}$; but it is now more uſual to expreſs them by accents over the ſame letter; as $\overset{\prime}{x}$.

Method of INCREMENTS, a branch of Analytics, in which a calculus is founded on the properties of the ſucceſſive values of variable quantities, and their differences or increments.

The inventor of the method of increments was the learned Dr Taylor, who, in the year 1715, publiſhed a treatiſe upon it; and afterwards gave ſome farther account and explication of it in the Philoſ. Tranſ. as applied to the finding of the ſums of ſeries. And another ingenious and eaſy treatiſe on the ſame, was publiſhed by Mr Emerſon, in the year 1763. The method is nearly allied to Newton's Doctrine of Fluxions, and ariſes out of it. Alſo the Differential method of Mr Stirling, which he applies to the ſummation and interpolation of ſeries, is of the ſame nature as the method of increments, but not ſo general and extenſive.

INDETERMINATE Problem. See Algebra, Part I Chap. VI. *Encycl.*

Diophantus was the firſt writer on indeterminate problems, which, after the publication of his work in 1621 by Bachet, employed much of the time of the moſt celebrated mathematicians in Europe. Afterwards ſuch problems were neglected as uſeleſs, till the public attention was again drawn to them by Euler and la Grange. The example of ſuch men was followed by Mr John Leſlie, a very eminent and ſelf-taught mathematician; who, in the ſecond vol. of the Tranſactions of the Royal Society of Edinburgh, has publiſhed an ingenious paper on indeterminate problems, reſolving them by a new and general principle. "The doctrine of indeterminate equations (ſays Mr Leſlie) has been ſeldom treated in a form equally ſyſtematic

Indeterminate, Induction.

with the other parts of algebra. The ſolutions commonly given are devoid of uniformity, and often require a variety of aſſumptions. The object of this paper is to reſolve the complicated expreſſions which we obtain in the ſolution of indeterminate problems, into ſimple equations, and to do ſo, without framing a number of aſſumptions, by help of a ſingle principle, which, though extremely ſimple, admits of a very extenſive application.

"Let $A \times B$ be any compound quantity equal to another, $C \times D$, and let m be any rational number aſſumed at pleaſure; it is manifeſt that, taking equimultiples, $A \times m B = C \times m D$. If, therefore, we ſuppoſe that $A = mD$, it muſt follow that $mB = C$, or $B = \frac{C}{m}$. Thus two equations of a lower dimenſion are obtained. If theſe be capable of farther decompoſition, we may aſſume the multiples n and p, and form four equations ſtill more ſimple. By the repeated application of this principle, an higher equation, admitting of diviſors, will be reſolved into thoſe of the firſt order, the number of which will be one greater than that of the multiples aſſumed."

For example, reſuming the problem at firſt given, viz. to find two rational numbers, the difference of the ſquares of which ſhall be a given number. Let the given number be the product of a and b; then by hypotheſis, $x^2 - y^2 = ab$; but theſe compound quantities admit of an eaſy reſolution, for $\overline{x+y} \times \overline{x-y} = a \times b$. If, therefore, we ſuppoſe $x + y = ma$, we ſhall obtain $x - y = \frac{b}{m}$; where m is arbitrary, and if rational, x and y muſt alſo be rational. Hence the reſolution of theſe two equations gives the values of x and y, the numbers ſought, in terms of m; viz.

$$x = \frac{m^2a + b}{2m}, \text{ and } y = \frac{m^2a - b}{2m}.$$

INDUCTION, in logic, is that proceſs of the underſtanding by which from a number of *particular* truths perceived by ſimple apprehenſion, and diligently compared together, we infer another truth which is always *general* and ſometimes *univerſal*. It is perhaps needleſs to obſerve, that in the proceſs of induction the truths to be compared muſt be of the ſame kind, or relate to objects having a ſimilar nature; for the mereſt tyro in ſcience knows that phyſical truths cannot be compared with moral truths, nor the truths of pure mathematics with either.

That the method of induction is a juſt logic, has been ſufficiently evinced elſewhere (ſee Logic, Part III. chap. V. and Philosophy, nº 73—78. *Encycl.*), and is now indeed generally admitted. It is even admitted by Britiſh philoſophers to be the only method of reaſoning by which any progreſs can be made in the phyſical ſciences; for the laws of Nature can be diſcovered only by accurate experiments, and by carefully noting the agreements and the differences, however minute, which are thus found among the phenomena apparently ſimilar. It is not, however, commonly ſaid that *induction* is the method of reaſoning employed by the mathematicians; and the writer of this article long thought, with others, that in pure geometry the reaſoning is ſtrictly *ſyllogiſtical*. Mature reflection, however, has led him to doubt, with Doctor Reid *, the truth of the generally received opinion, to donbt even whether by categorical ſyllogiſms any thing whatever can be proved.

To the idolaters of Ariſtotle we are perfectly aware that this will appear an extravagant paradox; but to the votaries of truth, we do not deſpair of making it very evident, that for ſuch doubts there is ſome foundation.

We are led into this diſquiſition to counteract, in ſome degree, what we think the pernicious tendency of the philoſophy of Kant, which attempts have been lately made to introduce into this country. Of this philoſophy we ſhall endeavour to give ſomething like a diſtinct view in the proper place. It is ſufficient to obſerve here, that it reſts upon the hypotheſis, that "we are in poſſeſſion of certain notions *à priori*, which are abſolutely *independent of all experience*, although the *objects of experience* correſpond with them; and which are diſtinguiſhed by *neceſſity* and ſtrict *univerſality*." Theſe innate and univerſal notions, Kant conſiders as a ſet of *categories*, from which is to be deduced all ſuch knowledge as deſerves the name of ſcience; and he talks, of courſe, or at leaſt his Engliſh tranſlators repreſent him talking, with great contempt, of inductive reaſoning, and ſubſtituting ſyllogiſtic demonſtration in its ſtead.

As his categories are not familiar to our readers, we ſhall, in this place, examine ſyllogiſms connected with the categories of Ariſtotle, which are at leaſt more intelligible than thoſe of Kant, and which, being likewiſe general notions, muſt, in argument, be managed in the ſame way. Now the fundamental axiom upon which every categorical ſyllogiſm reſts, is the well known propoſition, which affirms, that "whatever may be predicated of a whole *genus*, may be predicated of every *ſpecies* and of every *individual* comprehended under that genus." This is indeed an undoubted truth; but it cannot conſtitute a foundation for reaſoning from the *genus* to the *ſpecies* or the *individual;* becauſe we cannot poſſibly know what can be predicated of the *genus* till we know what can be predicated of all the *individuals* ranged under it. Indeed it is only by aſcertaining, through the medium of induction, what can be predicated, and what not, of a number of individuals, that we come to form ſuch notions as thoſe of *genera* and *ſpecies;* and therefore, in a ſyllogiſm ſtrictly categorical, the propoſitions, which conſtitute the *premiſes*, and are taken for granted, are thoſe alone which are capable of proof; whilſt the concluſion, which the logician pretends to demonſtrate, muſt be evident to intuition or experience, otherwiſe the premiſes could not be known to be true. The analyſis of a few ſyllogiſms will make this apparent to every reader.

Dr Wallis, who, to an intimate acquaintance with the Ariſtotelian logic, added much mathematical and phyſical knowledge, gives the following ſyllogiſm as a perfect example of this mode of reaſoning in the firſt figure, to which it is known that all the other figures may be reduced:—

Omne animal eſt *ſenſu præditum.*
Socrates eſt *animal.* Ergo
Socrates eſt *ſenſu præditus.*

Here the propoſition to be demonſtrated is, that Socrates is endowed with ſenſe; and the propoſitions aſſumed as ſelf-evident truths, upon which the demonſtration is to be built, are, that "every animal is endowed with ſenſe;" and that "Socrates is an animal." But how comes the demonſtrator to know that "every animal is endowed with ſenſe?" To this queſtion we are not aware of any anſwer which can be given, except this, that mankind have agreed to call every being, which they perceive to be endowed with ſenſe, an *animal*. Let this, then, be ſuppoſed the true anſwer: the next queſtion to be put to the demonſtrator is, How he comes to know that *Socrates* is an *animal?* If we have anſwered the former queſtion properly, or, in other words, if it be eſſential to this genus of beings to be endowed with ſenſe, it is obvious that he can know that Socrates is an *animal* only by perceiving him to be *endowed with ſenſe;* and therefore, in this ſyllogiſm, the propoſition to be proved is the very firſt of the three of which the truth is perceived; and it is perceived intuitively, and not inferred from others by a proceſs of reaſoning.

Though there are ten categories and five predicables, there are but two kinds of categorical propoſitions, viz Thoſe in which the property or accident is predicated of the ſubſtance to which it belongs, and thoſe in which the *genus* is predicated of the *ſpecies* or *individual*. Of the former kind is the propoſition pretended to be proved by the ſyllogiſm which we have conſidered; of the latter, is that which is proved by the following:

Quicquid ſenſu præditum, eſt animal.
Socrates eſt ſenſu præditus. Ergo
Socrates eſt animal.

That this is a categorical ſyllogiſm, legitimate in mode and figure, will be denied by no man who is not an abſolute ſtranger to the very firſt principles of the Ariſtotelian logic; but it requires little attention indeed to perceive that it proves nothing. The impoſition of names is a thing ſo perfectly arbitrary, that the being, or claſs of beings, which in Latin and Engliſh is called *animal*, is with equal propriety in Greek called ζωον, and in Hebrew [illegible]. To a native of Greece, therefore, and to an ancient Hebrew, the major propoſition of this ſyllogiſm would have been wholly unintelligible; but had either of thoſe perſons been told by a man of known veracity, and acquainted with the Latin tongue, that every thing endowed with ſenſe was, by the Romans, called *animal*, he would then have underſtood the propoſition, admitted its truth without heſitation, and have henceforth known that Socrates and Moſes, and every thing elſe which he perceived to be endowed with ſenſe, would at Rome be called *animal.* This knowledge, however, would not have reſted upon demonſtrative reaſoning of any kind, but upon the credibility of his informer, and the intuitive evidence of his own ſenſes.

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* Appendix to Vol. III of *Sketches of the Hiſtory of Man.*

It will perhaps be ſaid, that the two ſyllogiſms which we have examined are improper examples, becauſe the truth to be proved by the former is ſelf-evident, whilſt that which is meant to be eſtabliſhed by the latter is merely verbal, and therefore arbitrary. But the following is liable to neither of theſe objections:

All animals are *mortal.*
Man is *an animal;* therefore
Man is *mortal.*

Here it would be proper to aſk the demonſtrator, upon what grounds he ſo confidently pronounces all animals to be mortal? The propoſition is ſo far from expreſſing a ſelf-evident truth, that, previous to the entrance of ſin and death into the world, the firſt man had ſurely no conception of mortality. He acquired the notion, however, by experience, when he ſaw the animals die in ſucceſſion around him; and when he obſerved that no animal with which he was acquainted, not even his own ſon, eſcaped death, he would conclude that all animals, without exception, are mortal. This concluſion, however, could not be built upon ſyllogiſtic reaſoning, nor yet upon intuition, but partly upon experience and partly on analogy. As far as his experience went, the proof, by induction, of the mortality of all animals was complete; but there are many animals in the ocean, and perhaps on the earth, which he never ſaw, and of whoſe mortality therefore he could affirm nothing but from analogy, *i. e.* from concluding, as the conſtitution of the human mind compels us to conclude, that Nature is uniform throughout the univerſe, and that ſimilar cauſes, whether known or unknown, will, in ſimilar circumſtances, produce, at all times, ſimilar effects. It is to be obſerved of this ſyllogiſm, as of the firſt which we have conſidered, that the propoſition, which it pretends to demonſtrate, is one of thoſe truths known by experience, from which, by the proceſs of induction, we infer the major of the premiſes to be true; and that therefore the reaſoning, if reaſoning it can be called, runs in a circle.

Yet by a concatenation of ſyllogiſms have logicians pretended that a long ſeries of important truths may be diſcovered and demonſtrated; and even Wallis himſelf ſeems to think, that this is the inſtrument by which the mathematicians have deduced, from a few poſtulates, accurate definitions, and undeniable axioms, all the truths of their demonſtrative ſcience. Let us try the truth of this opinion by analyſing ſome of Euclid's demonſtrations.

In the ſhort article Principle (*Encycl.*), it has been ſhewn, that all our *firſt* truths are *particular*, and that it is by applying to them the rules of induction that we form general truths or axioms—even the axioms of pure geometry. As this ſcience treats not of real external things, but merely of *ideas* or *conceptions*, the creatures of our minds, it is obvious, that its definitions may be perfectly accurate, the induction by which its axioms are formed complete, and therefore the axioms themſelves *univerſal* propoſitions. The uſe of theſe axioms is merely to ſhorten the different proceſſes of geometrical reaſoning, and not, as has ſometimes been abſurdly ſuppoſed, to be made the *parents* or *cauſes* of *particular* truths. No truth, whether general or particular, can, in any ſenſe of the word, be the cauſe of another truth. If it were not true that all individual figures, of whatever form, comprehending a portion of ſpace equal to a portion comprehended by any other individual figure, whether of the ſame form with ſome of them, or of a form different from them all, are equal to one another, it would not be true that "things in *general*, which are equal to the ſame thing, or that magnitudes which coincide, or exactly fill the ſame ſpace," are reſpectively equal to one another; and therefore the firſt and eight of Euclid's axioms would be falſe. So far are theſe axioms, or general truths, from being the parents of particular truths, that, as conceived by us, they may, with greater propriety, be termed their *offſpring*. They are indeed nothing more than general expreſſions, comprehending all particular truths of the ſame kind. When a mathematical propoſition therefore is enounced, if the terms, of which it is compoſed, or the figures of which a certain relation is predicated, can be brought together and immediately compared, no demonſtration is neceſſary to point out its truth or falſehood. It is indeed intuitively perceived to be either comprehended under, or contrary to ſome known *axiom* of the ſcience; but it has the evidence of truth or falſehood in itſelf, and not in *conſequence* of that axiom. When the figures or ſymbols cannot be immediately compared together, it is then, and only then, that recourſe is had to demonſtration; which proceeds, not in a ſeries of ſyllogiſms, but by a proceſs of ideal menſuration or induction. A figure or ſymbol is conceived, which may be compared with each of the principal figures or ſymbols, or, if that cannot be, with one of them, and then another, which may be compared with it, till through a ſeries of well known intermediate relations, a compariſon is made between the terms of the original propoſition, of which the truth or falſehood is then perceived.

Thus in the 47th propoſition of the firſt book of Euclid's Elements, the author propoſes to demonſtrate the equality between the ſquare of the hypothenuſe of a right angled triangle, and the ſum of the ſquares deſcribed on the other two ſides; but he does not proceed in the way of categorical ſyllogiſms, by raiſing his demonſtration on ſome univerſal truth relating to the *genus of ſquares*. On the contrary, he proceeds to *meaſure* the three ſquares of which he has affirmed a certain relation; but as they cannot be immediately compared together, he directs the largeſt of them to be divided into two parallelograms, according to a rule which he had formerly aſcertained to be juſt; and as theſe parallelograms can, as little as the ſquare of which they are the conſtituent parts, be compared with the ſquares of the other two ſides of the triangle, he thinks of ſome intermediate figure which may be applied as a common meaſure to the ſquares and the parallelograms. Accordingly, having before found that a parallelogram, or ſquare, is exactly double of a triangle ſtanding on the ſame baſe and between the ſame parallels with it, he conſtructs triangles upon the ſame baſe, and between the ſame parallels with his parallelograms, and the ſquares of the ſides containing the right angle of the original triangle; and finding, by a proceſs formerly ſhewn to be juſt, that the triangles on the baſes of the parallelograms are preciſely equal to the triangles on the baſes of the ſquares, he perceives at once that the two parallelograms, of which the largeſt ſquare is compoſed, muſt be equal to the ſum of the two leſſer ſquares; and the truth of the propoſition is demonſtrated.

In the courſe of this demonſtration, there is not ſo much as one truth *inferred* from another by *ſyllogiſm*, but all are perceived in ſucceſſion by a ſeries of ſimple apprehenſions. Euclid, indeed, after finding the triangle conſtructed on the baſe of one of the parallelograms to be equal to the triangle conſtructed on the baſe of one of the ſquares, introduces an *axiom*, and ſays, "but the doubles of equals are equal to one another; *therefore* the parallelogram is equal to the ſquare." But if from this mode of expreſſion any man conceive the axiom or univerſal truth to be the *cauſe* of the truth more particular, or ſuppoſe that the *latter* could not be apprehended without a *previous* knowledge of the former, he is a ſtranger to the nature of evidence, and to the proceſs of *generalization*, by which axioms are formed.

If we examine the problems of this ancient geometrician, we ſhall find that the truth of them is proved by the very ſame means which he makes uſe of to point out the truth of his theorems. Thus, the firſt problem of his immortal work is, "to deſcribe an equilateral triangle on a given finite ſtraight line;" and not only is this to be done, but the method by which it is done muſt be ſuch as can be ſhewn to be incontrovertibly juſt. The ſides of a triangle, however, cannot be applied to each other ſo as to be immediately compared; for they are conceived to be immoveable among themſelves. A common meaſure, therefore, or ſomething equivalent to a common meaſure, muſt be found, by which the triangle may be conſtructed, and the equality of its three ſides afterwards evinced; and this equivalent Euclid finds in the *circle*.

By contemplating the properties of the circle, it was eaſy to perceive that all its *radii* muſt be equal to one another. He therefore directs two circles to be deſcribed from the oppoſite extremities of the given finite ſtraight line, ſo as that it may be the radius of each of them; and from the point in which the circles interſect one another, he orders lines to be drawn to the extreme points of the given line, affirming that theſe three lines conſtitute an equilateral triangle. To convince his reader of the truth of this affirmation, he has only to put him in mind, that from the properties of the circle, the lines which he has drawn muſt be each equal to the given line, and of courſe all the three equal to one another; and this mutual equality is perceived by ſimple apprehenſion, and not inferred by ſyllogiſtic reaſoning. Euclid, indeed, by introducing into the demonſtration his firſt axiom, gives to it the form of a ſyllogiſm: but that ſyllogiſm proves nothing; for if the equality of the three ſides of the triangle were not intuitively perceived in their poſition and the properties of the circle, the firſt axiom would itſelf be a falſehood. So true it is that categorical ſyllogiſms have no place in geometrical reaſoning; which is as ſtrictly experimental and inductive as the reaſoning employed in the various branches of phyſics.

But if this be ſo, how come the truths of pure geometry to be neceſſary, ſo that the contrary of any one of them is clearly perceived to be impoſſible; whilſt phyſical truths are all contingent, ſo that there is not one of them of which the direct contrary may not eaſily be conceived?

That there is not one phyſical truth, of which the contrary may not be conceived, is not perhaps ſo certain as has generally been imagined; but admitting the fact to be as it has commonly been ſtated, the apparent difference between this claſs of truths and thoſe of pure geometry, may be eaſily accounted for, without ſuppoſing that the former reſts upon a kind of evidence totally different from that which ſupports the fabric of the latter.

The objects of pure geometry, as we have already obſerved, are the creatures of our own minds, which contain in them nothing concealed from our view. As the mathematician treats them merely as meaſurable quantities, he knows, with the utmoſt preciſion, upon what particular properties the relation affirmed to ſubſiſt between any two or more of them muſt abſolutely depend; and he cannot poſſibly entertain a doubt but it will be found to have place among all quantities having the ſame properties, becauſe it depends upon them, and upon them alone. His proceſs of induction, therefore, by a ſeries of ideal meaſurements, is always complete, and exhauſts the ſubject; but in phyſical enquiries the caſe is widely different. The ſubjects which employ the phyſical enquirer are not his own ideas, and their various relations, but the properties, powers, and relations of the bodies which compoſe the univerſe; and of thoſe bodies he knows neither the ſubſtance, internal ſtructure, nor all the qualities: ſo that he can very ſeldom diſcover with certainty upon what particular property or properties the phenomena of the corporeal world, or the relations which ſubſiſt among different bodies, depend. He expects, indeed, with confidence, not inferior to that with which he admits a mathematical demonſtration, that any corporeal phenomenon, which he has obſerved in certain circumſtances, will be always obſerved in circumſtances exactly ſimilar; but the misfortune is, that he can very ſeldom be aſcertained of this ſimilarity. He does not know any one piece of matter *as it is in itſelf*: he cannot ſeparate its various properties; and of courſe cannot attribute to any one property the effects or apparent effects which proceed excluſively from it. Indeed, the properties of bodies are ſo cloſely interwoven, that by human means they cannot be completely ſeparated; and hence the moſt cautious inveſtigator is apt to attribute to ſome one or two properties, an event which in reality reſults perhaps from many. (See PHILOSOPHY and PHYSICS, *Encycl.*) This the geometrician never does. He knows perfectly that the relation of equality which ſubſiſts between the three angles of a plain triangle and two right angles, depends not upon the ſize of the triangles, the matter of which they are conceived to be made, the particular place which they occupy in the univerſe, or upon any one circumſtance whatever beſides their triangularity, and the angles of their corrolets being exactly right angles; and it is upon this power of diſcrimination which we have in the conceptions of pure geometry, and have not in the objects of phyſics, that the truths of the one ſcience are perceived to be neceſſary, while thoſe of the other appear to be contingent; though the mode of demonſtration is the ſame in both, or at leaſt equally removed from categorical ſyllogiſms.

INERTIA. See Dynamics and Impulsion in this *Supplement*

INFLAMMATION has been ſufficiently explained in the *Encyclopædia*, and in the article Chemistry in this *Supplement*; but it cannot be improper, in this place, to give an account of ſome remarkable

Spontaneous Inflammations, which, as different ſubſtances, are liable to them, have been, and may again be, the cauſe of many and great misfortunes.

The ſpontaneous inflammation of eſſential oils, and that of ſome fat oils, when mixed with nitrous acid, are well known to philoſophers; ſo alſo is that of powdered charcoal with the ſame acid (lately diſcovered by M. Prouſt), and thoſe of phoſphorus, of pyrophorus, and of fulminating gold. Theſe ſubſtances are generally to be found only in the laboratories of chemiſts, who are perfectly well acquainted with the precautions which it is neceſſary to take to prevent the unhappy accidents which may be occaſioned by them.

The burning of a ſtore houſe of ſails, which happened at Breſt in the year 1757, was cauſed by the ſpontaneous inflammation of ſome oiled cloths, which, after having been painted on one ſide and dried in the ſun, were ſtowed away while yet warm; as was ſhewn by ſubſequent experiments *.

Vegetables boiled in oil or fat, and left to themſelves, after having been preſſed, inflame in the open air. This inflammation always takes place when the vegetables retain a certain degree of humidity; if they are firſt thoroughly dried, they are reduced to aſhes, without the appearance of flame. We owe the obſervation of theſe facts to MM. Saladin and Carette †.

The heaps of linen rags which are thrown together in paper manufactories, the preparation of which is haſtened by means of fermentation, often take fire, if not carefully attended to.

The ſpontaneous inflammation of hay has been known for many centuries; by its means houſes, barns, &c. have been often reduced to aſhes. When the hay is laid up damp, the inflammation often happens; for the fermentation is then very great. This accident very ſeldom occurs to the firſt hay (according to the obſervation of M. de Bomare), but is much more common to the ſecond; and if, through inattention, a piece of iron ſhould be left in a ſtalk of hay in fermentation, the inflammation of that ſtalk is almoſt a certain conſequence. Corn heaped up has alſo ſometimes produced inflammations of this nature. Vanieri, in his *Prædium Ruſticum*, ſays,

> *Quæ vero (gramina) nondum ſatis inſolata recondens*
> *Imprudens, ſubitis pariunt incendia flammis.*

Dung alſo, under certain circumſtances, inflames ſpontaneouſly.

In a paper, publiſhed in the *Repertory of Arts and Manufactures*, by the Rev. William Tooke, F. R. S. &c. we have the following remarkable inſtances of ſpontaneous inflammation. "A perſon of the name of Rüde, an apothecary at Bautzen, had prepared a pyrophorus from rye-bran and alum. Not long after he had made the diſcovery, there broke out, in the next village of Nauſlitz, a great fire, which did much miſchief, and was ſaid to have been occaſioned by the treating of a ſick cow in the cow-houſe. Mr Rüde knew, that the countrymen were uſed to lay an application of parched rye-bran to their cattle for curing the thick neck; he knew alſo, that alum and rye-bran, by a proper proceſs, yielded a pyrophorus; and now he wiſhed to try whether parched rye bran alone would have the ſame effect. Accordingly, he roaſted a quantity of rye-bran by the fire, till it had acquired the colour of roaſted coffee. This roaſted bran he wrapped up in a linen cloth; in the ſpace of a few minutes there aroſe a ſtrong ſmoke through the cloth, accompanied by a ſmell of burning. Not long afterwards the rag grew as black as tinder, and the bran, now become hot, fell through it on the ground in little balls. Mr Rüde repeated the experiment at various times, and always with the ſame reſult. Who now will any longer doubt, that the frequency of fires in cow-houſes, which in thoſe parts are moſtly wooden buildings, may not be occaſioned by this common practice, of binding roaſted bran about the necks of the cattle? The fire, after conſuming the cattle and the ſhed, communicates itſelf to the adjoining buildings; great damage enſues; and the ignorant look for the cauſe in wilful and malicious firing, conſequently in a capital crime."

The ſame author informs us, that in the ſpring of the year 178 , a fire was diſcovered on board a Ruſſian frigate lying in the road of Cronſtadt; which, if it had not been timely extinguiſhed, would have endangered the whole fleet. After the ſevereſt ſcrutiny, no cauſe of the fire was to be found; and the matter was forced to remain without explanation, but with ſtrong ſurmiſes of ſome wicked incendiary being at the bottom of it. In the month of Auguſt, in the ſame year, a fire broke out at the hemp-magazine at St Peterſburgh, by which ſeveral hundred thouſand poods ‡ of hemp and flax were conſumed. The walls of the magazine are of brick, the floors of ſtone, and the rafters and covering of iron; it ſtands alone on an iſland in the Neva, on which, as well as on board the ſhips lying in the Neva, no fire is permitted. In St Peterſburgh, in the ſame year, a fire was diſcovered in the vaulted ſhop of a furrier. In theſe ſhops, which are all vaults, neither fire nor candle is allowed, and the doors of them are all of iron. At length the probable cauſe was found to be, that the furrier, the evening before the fire, had got a roll of new cere-cloth (much in uſe here for covering tables, counters, &c. being eaſily wiped and kept clean), and had left it in his vault, where it was found almoſt conſumed.

In the night between the 20th and 21ſt of April 1781, a fire was ſeen on board the frigate Maria, which lay at anchor, with ſeveral other ſhips, in the road off the iſland of Cronſtadt; the fire was, however, ſoon extinguiſhed; and, by the ſevereſt examination, little or nothing could be extorted concerning the manner in which it had ariſen. The garriſon was threatened with a ſcrutiny that ſhould coſt them dear; and while they were in this cruel ſtate of ſuſpence, an order came from the ſovereign, which quieted their minds, and gave riſe to ſome very ſatisfactory experiments.

It having been found, upon juridical examination, as well as private inquiry, that in the ſhip's cabin, when the ſmoke appeared, there lay a bundle of matting, containing Ruſſian lamp-black prepared from fir-ſoot, moiſtened with hemp oil varniſh, which was perceived

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* See *Memoires de l'Academie de Paris*, 1760.

† *Journal de Phyſique*, 1784.

‡ A pood conſiſts of 40 pounds Ruſs, or 36 Engliſh.

Inflammation.

to have ſparks of fire in it at the time of the extinction, the Ruſſian admiralty gave orders to make various experiments, in order to ſee whether a mixture of hemp-oil varniſh and the forementioned Ruſſian black, folded up in a mat and bound together, would kindle of itſelf.

They ſhook 40 pounds of fir-wood ſoot into a tub, and poured about 35 pounds of hemp oil varniſh upon it; this they let ſtand for an hour, after which they poured off the oil. The remaining mixture they now wrapped up in a mat, and the bundle was laid cloſe to the cabin, where the midſhipmen had their birth. To avoid all ſuſpicion of treachery, two officers ſealed both the mat and the door with their own ſeals, and ſtationed a watch of four ſea-officers, to take notice of all that paſſed the whole night through; and as ſoon as any ſmoke ſhould appear, immediately to give information to the commandant of the port.

The experiment was made the 26th of April, about 11 o'clock A. M. in preſence of all the officers named in the commiſſion. Early on the following day, about ſix o'clock A. M. a ſmoke appeared, of which the chief commandant was immediately informed by an officer: he came with all poſſible ſpeed, and through a ſmall hole in the door ſaw the mat ſmoking. Without opening the door, he diſpatched a meſſenger to the members of the commiſſion; but as the ſmoke became ſtronger, and fire began to appear, the chief commandant found it neceſſary, without waiting for the members of the commiſſion, to break the ſeals and open the door. No ſooner was the air thus admitted, than the mat began to burn with greater force, and preſently it burſt into a flame.

The Ruſſian admiralty, being now fully convinced of the ſelf-enkindling property of this compoſition, tranſmitted their experiment to the Imperial Academy of Sciences; who appointed Mr Georgi, a very learned and able adjunct of the academy, to make farther experiments on the ſubject. Previous to the relation of theſe experiments, it is neceſſary to obſerve, that the Ruſſian fir-black is three or four times more heavy, thick, and unctuous, than that kind of painters black which the Germans call *kien-rahm*. The former is gathered at Ochta, near St Peterſburgh, at Moſco, at Archangel, and other places, in little wooden huts, from reſinous fir-wood, and the unctuous bark of birch, by means of an apparatus uncommonly ſimple, conſiſting of pots without bottoms ſet one upon the other; and is ſold very cheap. The famous fine German *kien-rahm* is called in Ruſſia *Holland's black*. In what follows, when raw oil is ſpoken of, it is to be underſtood of linſeed-oil or hemp oil; but moſt commonly the latter. The varniſh is made of five pounds of hemp-oil boiled with two ounces and a half of minium. For wrapping up the compoſition, Mr Georgi made uſe of coarſe hemp-linen, and always ſingle, never double. The impregnations and commixtures were made in a large wooden bowl, in which they ſtood open till they were wrapped up in linen.

Three pounds of Ruſſian fir-black were ſlowly impregnated with five pounds of hemp-oil varniſh; and when the mixture had ſtood open five hours, it was bound up in linen. By this proceſs it became clotted; but ſome of the black remained dry. When the bundle had lain ſixteen hours in a cheſt, it was obſerved to emit a very nauſeous, and rather putrid, ſmell, not quite unlike that of boiling oil. Some parts of it became warm, and ſteamed much; this ſteam was watery, and by no means inflammable. Eighteen hours after the mixture was wrapped up, one place became brown, emitted ſmoke, and directly afterwards glowing fire appeared. The ſame thing happened in a ſecond and a third place, though other places were ſcarcely warm. The fire crept ſlowly around, and gave a thick, grey, ſtinking ſmoke. Mr Georgi took the bundle out of the cheſt, and laid it on a ſtone pavement; when, on being expoſed to the free air, there aroſe a ſlow burning flame, a ſpan high, with a ſtrong body of ſmoke. Not long afterwards there appeared, here and there, ſeveral chaps or clefts, as from a little volcano, the vapour iſſuing from which burſt into flame. On his breaking the lump, it burſt into a very violent flame, full three feet high, which ſoon grew leſs, and then went out. The ſmoking and glowing fire laſted for the ſpace of ſix hours; and afterwards the remainder continued to glow without ſmoke for two hours longer. The grey earthy aſhes, when cold, weighed five ounces and a half.

Inflammation.

In another experiment, perfectly ſimilar to the foregoing, as far as relates to the compoſition and quantities, the enkindling did not enſue till 41 hours after the impregnation: the heat kept increaſing for three hours, and then the accenſion followed. It is worthy of remark, that theſe experiments ſucceeded better on bright days than on ſuch as were rainy; and the accenſion came on more rapidly.

In another experiment, three pounds of Ruſſian fir-black were ſlowly impregnated with three pounds of raw hemp-oil; and the accenſion enſued after nine hours.

Three quarters of a pound of German *rahm* were ſlowly impregnated with a pound and a half of hemp-oil varniſh. The mixture remained 70 hours before it became hot and reeking; it then gradually became hotter, and emitted a ſtrong exhalation; the effluvia were moiſt, and not inflammable. The reaction laſted 36 hours, during which the heat was one while ſtronger, and then weaker, and at length quite ceaſed.

Stove or chimney ſoot, moſtly formed from birch-wood ſmoke, was mingled with the above-mentioned ſubſtances and tied up; the compound remained cold and quiet.

Ruſſian fir-black, mixed with equal parts of oil of turpentine, and bound up, exhibited not the leaſt reaction or warmth.

Birch oil, mixed with equal parts of Ruſſian fir-black, and bound up, began to grow warm and to emit a volatile ſmell; but the warmth ſoon went off again.

From the experiments of the admiralty and of Mr Georgi, we learn, not only the deciſive certainty of the ſelf-accenſion of ſoot and oil, when the two ſubſtances are mixed under certain circumſtances, but alſo the following particulars:

Of the various kinds of ſoot, or lamp-black, the experiments ſucceeded more frequently and ſurely with the coarſer, more unctuous, and heavier, like Ruſſian painters black, than with fine light German *rahm*, or with coarſe chimney-ſoot. In regard to oils, only thoſe experiments ſucceeded which were made with drying oils, either raw or boiled. The proportions of the ſoots to the oils were, in the ſucceſsful experiments, very various; the mixture kindled with a tenth, a fifth, a third, with an equal, and likewiſe with a double, proportion of oil. In general, however, much more depends on the mode of mixture, and the manipulation, and, as Mr Georgi often obſerved, on the weather; for in moiſt weather the bundles, after becoming warm, would frequently grow cold again.

The inſtances of ſpontaneous inflammation hitherto mentioned have been only of vegetable ſubſtances; but we have examples of the ſame thing in the animal kingdom. Pieces of woollen cloth, which had not been ſcoured, took fire in a warehouſe. The ſame thing happened to ſome heaps of woollen yarn; and ſome pieces of cloth took fire in the road, as they were going to the fuller. Theſe inflammations always take place where the matters heaped up preſerve a certain degree of humidity, which is neceſſary to excite a fermentation; the heat reſulting from which, by drying the oil, leads them inſenſibly to a ſtate of ignition; and the quality of the oil, being more or leſs deſiccative, very much contributes thereto.

The woollen ſtuff prepared at Sevennes, which bears the name of Emperor's ſtuff, has kindled of itſelf, and burnt to a coal. It is not unuſual for this to happen to woollen ſtuffs, when in hot ſummers they are laid in a heap in a room but little aired.

In June 1781, the ſame thing happened at a woolcomber's in a manufacturing town in Germany, where a heap of wool-combings, piled up in a cloſe warehouſe ſeldom aired, took fire of itſelf. This wool had been by little and little brought into the warehouſe; and, for want of room, piled up very high, and trodden down, that more might be added to it. That this combed wool, to which, as is well known, rape-oil mixed with butter is uſed in the combing, burnt of itſelf, was ſworn by ſeveral witneſſes. One of them affirmed that, ten years before, a ſimilar fire happened among the flocks of wool at a clothier's, who had put them into a caſk, where they were rammed hard, for their eaſier conveyance. This wool burnt from within outwards, and became quite a coal; it was very certain that neither fire nor light had been uſed at the packing, conſequently the above fires aroſe from ſimilar cauſes. In like manner, very credible cloth-workers have certified, that, after they have bought wool that was become wet, and packed it cloſe in their warehouſe, this wool has burnt of itſelf; and very ſerious conſequences might have followed, if it had not been diſcovered in time.

Nay, there are inſtances, though they be but rare, of human bodies being conſumed by ſpontaneous inflammation. In the Philoſophical Tranſactions, and in the Memoirs of the Academies of Paris and Copenhagen, it is related that an Italian lady (the Counteſs Cornelia Bandi) was entirely reduced to aſhes, except her legs; that an Engliſh woman, called Grace Pitt, was almoſt entirely conſumed by a ſpontaneous inflammation of her viſcera; and, laſtly, that a prieſt of Bergamo was conſumed in the ſame manner. Theſe ſpontaneous inflammations have been attributed to the abuſe of ſpirituous liquors; but though the victims of intemperance are indeed very numerous, theſe certainly do not belong to that number.

The mineral kingdom alſo often affords inſtances of ſpontaneous inflammation. Pyrites heaped up, if wetted and expoſed to the air, take fire. Pitcoal alſo, laid in heaps, under certain circumſtances, inflames ſpontaneouſly. M. Duhamel has deſcribed two inflammations of this nature, which happened in the magazines of Breſt, in the years 1741 and 1757. Cuttings of iron, which had been left in water, and were afterwards expoſed to the open air, gave ſparks, and ſet fire to the neighbouring bodies. For this obſervation we are obliged to M. de Charpentier.

The cauſes of theſe phenomena the chemiſt will aſſign; but they are here recorded as a warning to tradeſmen and others. It is evident, from the facts which have been related, that ſpontaneous inflammations being very frequent, and their cauſes very various, too much attention and vigilance cannot be uſed to prevent their dreadful effects. And conſequently it is impoſſible to be too careful in watching over public magazines and ſtorehouſes, particularly thoſe belonging to the ordnance, or thoſe in which are kept hemp, cordage, lamp-black, pitch, tar, oiled cloths, &c. which ſubſtances ought never to be left heaped up, particularly if they have any moiſture in them. In order to prevent any accident from them, it would be proper to examine them often, to take notice if any heat is to be obſerved in them, and, in that caſe, to apply a remedy immediately. Theſe examinations ſhould be made by day, it not being adviſable to carry a light into the magazines; for when the fermentation is ſufficiently advanced, the vapours which are diſengaged by it are in an inflammable ſtate, and the approach of a light might, by their means, ſet fire to the ſubſtances whence they proceed. Ignorance of the fore-mentioned circumſtances, and a culpable negligence of thoſe precautions which ought to be taken, have often cauſed more misfortunes and loſs than the moſt contriving malice: it is therefore of great importance that theſe facts ſhould be univerſally known, that public utility may reap from them every poſſible advantage.

INFORMED STARS, or INFORMES STELLÆ, are ſuch ſtars as have not been reduced into any conſtellation; otherwiſe called Sporades.—There was a great number of this kind left by the ancient aſtronomers; but Hevelius, and ſome others of the moderns, have provided for the greater part of them, by making new conſtellations.

SYMPATHETIC INK is an old invention. Among the methods by which Ovid teaches young women to deceive their guardians, when they write to their lovers, he mentions that of writing with new milk, and of making the writing legible by coal-duſt or ſoot.

Tuta quoque eſt, fallitque oculos, e lacte recenti
Litera: carbonis pulvere tange, leges.

It is obvious, that any other colourleſs and glutinous juice, which will hold faſt the black powder ſtrewed over it, will anſwer the purpoſe as well as milk; and therefore Pliny recommends the milky juice of certain plants to be uſed.

There are ſeveral metallic ſolutions perfectly colourleſs, or, at leaſt, without any ſtrong tint, which being wrote with, the letters will not appear until the paper be waſhed over with another colourleſs ſolution, or expoſed to the vapour of it; but among all theſe there is none which excites more aſtoniſhment, or from which naturaliſts can draw more concluſions, than that which conſiſts of a ſolution of lead in vegetable acid, and which by the vapour of arſenical liver of ſulphur becomes black, even at a conſiderable diſtance. This ink, which may be uſed by conjurors, proves the ſubtlety of vapour, and the poroſity of bodies; as the change or colouring takes place even when the writing is placed on the other ſide of a thin wall.

We knew before, that a ſolution of lead, treated in this manner, would anſwer the purpoſe of a ſympathetic ink (ſee that article *Encycl.*); but we did not know, nor do we yet believe, that the ſulphuric vapours will act upon the writing through *a wall.* Such, however, is the affirmation of Profeſſor Beckmann, who gives an account of a ſtill more wonderful ink from Peter Borel. This author, in a book called *Hiſtoriarum et obſervationum medico-phyſic. centuriæ quatuor*, printed at Paris, firſt in 1653, and afterwards in 1657, gives a receipt for making this ink, which he calls *magnetic waters which act at a diſtance.* The receipt is as follows:

"Let quick lime be quenched in common water, and while quenching, let ſome orpiment be added to it (this, however, ought to be done by placing warm aſhes under it for a whole day), and let the liquor be filtered, and preſerved in a glaſs bottle well corked. Then boil litharge of gold, well pounded, for half an hour with vinegar, in a braſs veſſel, and filter the whole through paper, and preſerve it alſo in a bottle cloſely corked. If you write any thing with this laſt water, with a clean pen, the writing will be inviſible when dry; but if it be waſhed over with the firſt water it will become inſtantly black. In this, however, there is nothing aſtoniſhing; but this is wonderful, that though ſheets of paper without number, and even a board, be placed between the inviſible writing and the ſecond liquid, it will have the ſame effect, and turn the writing black, penetrating the wood and paper without leaving any traces of its action, which is certainly ſurpriſing; but a fetid ſmell, occaſioned by the mutual action of the liquids, deters many from making the experiment. I am, however of opinion, that I could improve this ſecret by a more refined chemical preparation, ſo as that it ſhould perform its effect through a wall. This ſecret (ſays Borel) I received, in exchange for others, from J. Broſſon, a learned and ingenious apothecary of Montpelier."

For making a ſympathetic ink of the fifth claſs mentioned in the *Encyclopædia*, the following proceſs by M. Meyer may be worthy of the reader's notice. It was entered upon in conſequence of a receipt for roſe-coloured ſympathetic ink ſhewn to him by a traveller. In that receipt cobalt was the principal ingredient, and therefore the firſt object was to procure cobalt; but M. Meyer, being unwilling to ſacrifice pure pieces of cobalt of any conſiderable ſize, made choice of one, which was viſibly mixed with biſmuth, iron, and quartz. He endeavoured to ſeparate the biſmuth as much as poſſible, and alſo the arſenic, if it ſhould contain any, by bringing it ſlowly to a red heat; and he ſucceeded pretty well, as the biſmuth flowed from it in abundance; and the arſenic, the quantity of which was ſmall, was volatiliſed: many globules of biſmuth ſtill adhered to it. By bringing it repeatedly to a red heat, and then quenching it in water, it was reduced to ſuch a ſtate as to be eaſily pulveriſed. Having poured nitrous acid upon the powder, he obtained by digeſtion a beautiful roſe red ſolution; the ſiliceous earth was ſeparated in the form of a white ſlime, and by diluting it with water there was depoſited a white powder, which was oxyd of biſmuth. The ſolution being filtered, he added to it a ſolution of potaſh, and obtained a precipitate inclining more to a yellow than to a red colour. He again poured over it a little of the nitrous acid, by which a part of the oxyd was re-diſſolved of a red colour: the remaining part, which had a dark brown colour, was oxyd of iron. From the ſolution, by the addition of potaſh, a precipitate was formed, which was now reddiſh. Having by this proceſs obtained it pure, that he might now prepare from it the wiſhed for red ink, he diſſolved the waſhen pure oxyd of cobalt in different acids. That diſſolved in the nitrous acid with a mixture of nitre, gave a green ink like the common: that diſſolved in the ſulphurous acid, without the addition of ſalts, gave a reddiſh ink, which remained after it was expoſed to heat, and would not again diſappear, even when a ſolution of nitre was applied; and that diſſolved in the muriatic acid, gave a green ink, darker and more beautiful than the common. By diſſolving it, however, in the acetous acid, and adding a little nitre, he obtained what he had in view; for it gave, on the application of heat, an ink of a red colour, like that of the *roſa centifolia*, which again diſappeared when the paper became cold.

INORDINATE Proportion, is where the order of the terms compared is diſturbed or irregular. As, for example, in two ranks of numbers, three in each rank, viz. in one rank, - - - 2, 3, 9,
and in the other rank, - - - 8, 24, 36,
which are proportional, the former to the latter, but in a different order, viz. - - 2 : 3 :: 24 : 36,
and - - 3 : 9 :: 8 : 24.
then, caſting out the mean terms in each rank, it is concluded that - - - - 2 : 9 :: 8 : 36,
that is, the firſt is to the 3d in the firſt rank,
as the firſt is to the 3d in the 2d rank.

INSECTS (See *Encycl.*). A number of non-deſcript little animals was diſcovered by La Martiniere the naturaliſt when accompanying Perouſe on his celebrated voyage of diſcovery. Theſe animals he called *inſects*, and to many of them he gave particular names. Of theſe we ſhall give his deſcription in this place, leaving our readers, as he has left his, to arrange them properly according to the Linnæan claſſification.

Plate XXX.

"The inſect, which is figured N° 1. inhabits a ſmall priſmatic triangular cell, pointed at the two extremities, of the conſiſtence and colour of clear brittle ice; the body of the inſect is of a green colour, ſpotted with ſmall bluiſh points, among which are ſome of a golden tinge; it is fixed by a ligament to the lower part of its ſmall habitation: its neck is terminated by a ſmall blackiſh head compoſed of three converging ſcales, in the form of a hat, and encloſed between three fins, two of them large and channelled in the upper part (A) and one ſmall, ſemicircular (B). When it is diſturbed, it immediately withdraws its fins and its head into its cell, and gradually ſinks into the water by its own ſpecific gravity. Fig. 2. repreſents the under ſide of the priſm, ſhewing in what manner it is channelled, in order to allow free paſſage to the animal when it wiſhes to ſhut itſelf up in it. Fig. 3. repreſents the profile of the ſame. The movement carried on by the two larger fins, which are of a ſoftiſh cartilaginous ſubſtance, may be compared to that which would be produced by the two hands joined together in the ſtate of pronation, and forming, alternately, two inclined planes and one horizontal plane: it is by means of this motion that it ſupports itſelf on the top of the water, where it probably feeds on fat and oily ſubſtances on the ſurface of the ſea." Our author found it near Nootka, on the north-weſt coaſt of America, during a calm.

Fig. 4. repreſents a collection of inſects, as our author calls them, conſiſting only of oval bodies, ſimilar to a ſoap bubble, arranged in parties of three, five, ſix, and nine: among them are alſo ſome ſolitary ones. Theſe collections of globules, being put into a glaſs filled with ſea-water, deſcribed a rapid circle round the glaſs by a common movement, to which each individual contributed by ſimple compreſſion of the ſides of its body, probably the effect of the re-action of the air with which they were filled. It is not, however, eaſy to conceive how theſe diſtinct animals (for they may be readily ſeparated without deranging their economy) are capable of concurring in a common motion. "Theſe conſiderations (ſays our author), together with the form of the animal, recalled to my mind, with much ſatisfaction, the ingenious ſyſtem of M. de Buffon; and I endeavoured to perſuade myſelf, that I was about to be witneſs to one of the moſt wonderful phenomena of Nature, ſuppoſing that theſe molecules, which were now employed in increaſing or diminiſhing their number, or performing their revolutions in the glaſs, would ſoon aſſume the form of a new animal of which they were the living materials. My impatience led me to detach two from the moſt numerous group, imagining that this number might perhaps be more favourable to the expected metamorphoſis. I was, however, miſtaken. Theſe I examined with more attention than the reſt; and the following account is of their proceedings alone. Like two ſtrong and active wreſtlers, they immediately ruſhed together, and attacked each other on every ſide: ſometimes one would dive, leaving its adverſary at the ſurface of the water; one would deſcribe a circular movement, while the other remained at reſt in the centre; their motions at length became ſo rapid as no longer to allow me to diſtinguiſh one from the other. Having quitted them for a ſhort time, on my return I found them reunited as before, and amicably moving round the edge of the glaſs by their common exertions."

Fig. 5. repreſents a ſingular animal, which has a conſiderable reſemblance to a little lizard; its body is of a firm, gelatinous conſiſtence; its head is furniſhed on each ſide with two ſmall gelatinous horns, of which the two hindermoſt are ſituate the furtheſt inward: its body is provided with four open fan-like paws, and ſome appendages near the inſertion of the tail, and terminates like that of a lizard: the ridge of the back is divided the whole way down by a band of a deep blue; the reſt of the body, as well as the inſide of its paws, is of a bright ſilvery white. It appears to be very ſluggiſh in its motions; and when diſturbed by the finger, merely turned itſelf belly upwards, ſoon afterwards reſuming its former poſition. Fig. 6. repreſents it reverſed. Martiniere caught it during a calm at the landing place on the Baſhee Iſlands.

INSTITUTE is a name which has lately been ſubſtituted for *ſchool* or *academy*. Formerly *inſtitution*, in the propriety of the Engliſh language, was ſometimes uſed as a word of the ſame import with *inſtruction*; and now *inſtitute* is employed, eſpecially by the admirers of French innovations, to denote what had hitherto been called an academy. When royalty was aboliſhed in France, it would have been abſurd to continue the titles *Royal* Academy of Sciences, *Royal* Academy of Inſcriptions, &c.; but inſtead of merely aboliſhing the word *royal*, and ſubſtituting *national* in its ſtead, it occurred to the fertile brain of Condorcet, to aboliſh the ſeven academies themſelves, or rather to melt them all down into one great academy; to which was given the appellation of the

National Institute, or *New Academy of Arts and Sciences*. This academy, founded on a decree of the new conſtitution, was opened on the 7th of December 1795, when Benezech, the then miniſter for the home department, attended, and the decree of foundation was read; which was to the following purport:

"The Academy of Arts and Sciences belongs to the whole republic, and Paris is its place of reſidence. Its employment is to aim at bringing all arts and ſciences to the utmoſt perfection of which they are capable. It is to notice every new attempt, and all new diſcoveries, and to keep up a correſpondence with all foreign literary ſocieties. And by the particular orders of the Executive Directory, its firſt ſtudies are to be directed to thoſe ſubjects which more immediately tend to the reputation and advantage of the French republic."

The academy is to conſiſt of 288 members, half of whom are to reſide in Paris, the other half in the departments; and to them is to be added a certain number of foreigners, as honorary members, confined at preſent to twenty-four.

The academy is divided into three claſſes, each claſs into ſections, each ſection to contain twelve members.

1ſt claſs. Mathematics and natural philoſophy. This claſs is divided into ten ſections. 1. Mathematics. 2. Mechanical arts. 3. Aſtronomy. 4. Experimental philoſophy. 5. Chemiſtry. 6. Natural hiſtory. 7. Botany. 8. Anatomy and animal hiſtory. 9. Medicine and ſurgery. 10. Animal œconomy, and the veterinary ſcience.

2d claſs. Morality and politics. This claſs conſiſts of ſix ſections. 1. Analyſis of ſenſations and ideas. 2. Morals. 3. Legiſlature. 4. Political economy. 5. Hiſtory. 6. Geography.

3d claſs. Literature and the fine arts. This claſs conſiſts of eight ſections. 1. Univerſal grammar. 2. Ancient languages. 3. Poetry. 4. Antiquities. 5. Painting. 6. Sculpture. 7. Architecture. 8. Muſic.

For each claſs a particular room in the Louvre is appropriated. No one can be a member of two claſſes at the ſame time, but a member of one claſs may be preſent at the meetings of any other. Each claſs is to print, yearly, an account of its tranſactions.

Four times a-year there are to be public meetings. On theſe occaſions, the three claſſes meet together. At the end of each year, they are to give a circumſtantial account to the legiſlative body of the progreſs made in that year in the arts and ſciences. The prizes given yearly by each claſs are to be publicly notified at certain times. The ſums requiſite for the ſupport of the inſtitution are to be decreed yearly by the legiſlative body, upon a requiſition made by the Executive Directory.

The firſt forty-eight members were choſen by the Executive Directory, to whom the choice of the remaining members was confided. To the members, reſidentiary in Paris, is reſerved the choice both of the department and the foreign members. On a vacancy in any claſs, three candidates are named by the claſs for the choice of the body at large.

Each claſs is to have, at its place of meeting, a collection of the products, both of nature and art, and a library, according to its particular wants.

The regulations of the inſtitution, with reſpect to the times of meeting, and its employments, are to be drawn up by the body at large, and laid before the legiſlative aſſembly.

The hall in which the body at large holds its meetings, forms part of the weſt wing of the Old Louvre, at preſent called the Muſeum. It formerly went by the appellation of the Hall of Antiques (*Salle des Antiques*); and as long as the kings inhabited this part of the palace, was occupied by their guards, from which circumſtance it obtained the name of the Hall *des Cent Suiſſes*. It was likewiſe appropriated to banquets and entertainments, given by the court on gala days; and it was to this place that Henry IV. was conveyed, on his aſſaſſination by Ravaillac, in the *Rue de la Ferronnerie*.

It was built at the ſame time with the reſt of this part of the Louvre, about the year 1528, after the deſigns of Pierre Leſcot, abbot of Clagny. It is 144 feet in length, and 40 in breadth, and holds from 1000 to 1200 perſons. In order to adapt it to its new deſtination, the floor has been ſunk, which gives a greater air of lightneſs to the roof. In the centre ſtands a double table, in the form of a horſe-ſhoe, ſupported by ſphinxes, at which the members of the inſtitute take their ſeats. This table is ſurrounded by two tiers of benches, which are raiſed for the accommodation of ſpectators, who have likewiſe ſeats provided for them in the vaſt embraſures of the windows, and at each extremity of the hall.

Whether ſcience will be advanced by the ſeven royal academies having been melted into one, time muſt determine; but candour compels us to acknowledge, that the proceedings of the national inſtitute have hitherto been abundantly intereſting. Intimately connected with the national inſtitute is the French ſyſtem of

National Instruction, which is likewiſe novel, and therefore ſufficiently curious to deſerve notice in a Work of this kind. When the Chriſtian religion was aboliſhed in France, it was impoſſible to continue the univerſities and other ſeminaries which were founded by Chriſtians, and obliged by their conſtitution to teach, whether pure or not, the doctrines of Chriſtianity. They were accordingly all ſwept away, and a new ſyſtem of education planned, which was to be carried on in what they call

The Primary Schools.
The Central Schools.
The School of Health.
The School of Oriental Languages.
The Polytechnic School.
The National Inſtitute.
The Jury of Public Inſtruction.
The Commiſſion of Public Inſtruction.
The Legiſlative Committee of Inſtruction. And various other national eſtabliſhments for the improvement of particular ſciences.

The firſt degree of public inſtruction is to be met with in the *Ecoles Primarées*, eſtabliſhed by a decree of the convention of the ſecond *Pluvioſe*, in the ſecond year of the republic (A). Every diſtrict is furniſhed with one of theſe ſchools; the profeſſors or maſters in which are paid from the national treaſury; and to which every head of a family, without exception, is compelled by law to ſend its children for inſtruction. The ſubjects taught in theſe primary or elementary ſchools are divided into nine claſſes:

1*ſt*, Inſtructions connected with the phyſical and moral ſituation of children, prior to their entering into theſe ſchools. 2*d*, Similar inſtructions as a guide to teachers in the national ſchools. 3*d*, The arts of reading and writing. 4*th*, The elements of French grammar. 5*th*, Elements of arithmetic and geometry, with the theory of the new menſuration. 6*th*, The elements of geography. 7*th*, Explanations of the principal phenomena and productions of nature. 8*th*, Elements of agriculture. 9*th*, Elements of republican morals.

Next to the primary ſchools in rank and conſequence are the *Ecoles Centrales*, which were eſtabliſhed by a decree of the Convention of the ſeventh *Ventoſe* in the third year. They are ſituated in the capital of every department, bearing the proportion of one central ſchool to 300,000 inhabitants. In theſe ſchools the republican youths are taught the ſciences, and their application in real life. In each of them are profeſſors for the following branches:

1. For mathematics. 2. Experimental philoſophy and chemiſtry. 3. Natural hiſtory. 4. Agriculture and commerce. 5. Logic and metaphyſics. 6. Political economy and legiſlation. 7. The philoſophical hiſtory of nations. 8. The art of healing. 9. Arts and manufactures. 10. Univerſal grammar. 11. The belles lettres. 12. The ancient languages. 13. The modern languages. 14. The fine arts.

Each central ſchool is furniſhed with an extenſive public library—a botanic garden—a cabinet of natural hiſtory—an apparatus for experimental philoſophy—and a collection of machines and models connected with the arts and manufactures.

The profeſſors of each ſchool hold, every month, a public ſitting, in which conferences are held relative to ſubjects connected with the improvement of letters, the ſciences, and the arts, which are the moſt beneficial to ſociety.

The object in the eſtabliſhment of the primary and central ſchools was, the general inſtruction of all claſſes of the citizens; and it being incompatible with the perfect completion of that important purpoſe, to expect from them the propagation of particular branches of ſcience, it became neceſſary to eſtabliſh other literary and ſcientific academies.

Accordingly, the French government have founded, 1*ſt*, Schools of health (*les ecoles de ſante*), in Paris, Straſburgh, and

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(A) We would tranſlate this chronological jargon into the language of Chriſtian Europe, were we not perſuaded that the French calendar, the French conſtitution, and the French inſtitutes, will have the ſame duration: we truſt in God not a long duration, For *Pluvioſe*, and the other fantaſtical names of months introduced into this article, ſee Revolution, *Encycl.* n° 184.

and Montpelier, where medicine and ſurgery are ſtudied; which ſchools are affirmed, by thoſe who find nothing wrong in France, to be the moſt perfect of their kind, as well as new and unparalleled models for ſuch inſtitutions.

2*d*, Two ſchools for Oriental languages, in the national library, and in the college of France.

3*d*, The Polytechnic ſchool in Paris, or central ſchool for the direction of public works. This eſtabliſhment is very generally admired and conſidered as a model for imitation. It contains more than 400 young perſons, previouſly educated in the mathematics, and the majority of them intended for engineers in various lines; and they labour under the immediate direction of their tutors nine hours every day. It occupies the principal part of the *Palais de Bourbon* in Paris, and is furniſhed with a large collection of inſtruments and models. The journal of the Polytechnic ſchool, which is publiſhed by the bookſellers Regent and Bertrand at Paris, is a perfectly original work, and admirably calculated to convey uſeful information.

Of the national inſtitute a ſufficient account has been given in the preceding article. We proceed therefore to the jury of public inſtruction (*Le Jury Central d'Inſtruction*), of which the principal buſineſs is to ſuperintend the primary and central ſchools. It appoints the profeſſors in theſe ſchools, and examines into their conduct. Like the legiſlative body it is renewed by a third every half year. When they have choſen a profeſſor for a central ſchool, they ſubmit their choice to the department; and, in caſe of diſapprobation, they make another appointment. To this jury of public inſtruction the profeſſors in the central ſchools are amenable for all miſconduct connected with their offices; it may expel them, but all its deciſions muſt be ſubmitted for confirmation to the tribunal of the department.

There is alſo eſtabliſhed at Paris a ſupreme council, called The Commiſſion of Public Inſtruction, to which is entruſted the whole executive department. The preſervation of the national monuments, of public libraries, muſeums, cabinets, and valuable collections; the ſuperintendance of all the ſchools and the modes of inſtruction; all new inventions and ſcientific diſcoveries; the regulation of weights and meaſures; national ſtatiſtics and political economy, are all placed under the authority of this ſupreme commiſſion. For the commodious and regular execution of ſo many complicated branches of buſineſs, there is a large office, called *Le Secretariat*, which is divided into three departments.

1. For the regulation of the different kinds of inſtruction; of the modes of education in the ſchools; and for the choice of elementary books. 2. For weights and meaſures; inventions and diſcoveries; libraries and bibliography; muſeums, works of art, and literary rewards and encouragements. 3. For theatres, national feaſts, republican inſtitutions, and the erection of monuments.

As all public eſtabliſhments require the ſuperintendance and occaſional correction of the legiſlature, in addition to that of their own immediate executive authority, it has been deemed neceſſary to appoint a permanent committee of inſtruction in the legiſlative body, to provide ſuch ſums as may be neceſſary for the preſervation and improvement of this ſyſtem of inſtruction. This legiſlative committee are inveſted with due authority for theſe purpoſes. Their objects are preciſely the ſame as thoſe of the commiſſion of public inſtruction above deſcribed, only with this difference, that the latter ſuperintends the execution of exiſting laws, whilſt the former receives and improves them, or propoſes new ones. This committee is divided into three departments, as is the commiſſion, with exactly the ſame arrangement of their reſpective labours. The committee being charged with the enaction of all new laws, its members, with a view to obtain accurately all the requiſite information relative to the numerous branches of the arts, have procured from the legiſlative body the appointment of a *commiſſion temporaire des arts* to be annexed to them, and to meet in the ſame houſe with them; which temporary commiſſion is divided into ſixteen claſſes: viz. 1. For Zoology; 2. Botany; 3. Mineralogy; 4. Phyſics; 5. Chemiſtry; 6. Anatomy; 7. Machinery; 8. Geography; 9. Artillery and Fortification; 10. Medals and Antiquities; 11. Bibliography; 12. Painting; 13. Architecture; 14. Sculpture; 15. Bridges and Cauſeways; and, 16. Muſical Inſtruments.

The improvements of the national literary and ſcientific eſtabliſhments are numerous and important.

1*ſt*, By a decree of the convention of the 11th *Prairial*, in the ſecond year, it was enacted, that means ſhould be adopted by which every poſſible advantage might be derived from the botanic gardens of the republic, in Turkey and other foreign countries. This politic decree clearly tended to render France, in the language of the reporter, *L'abregé de tous les climats, et l'entrepôt de l'Europe.* "The epitome of every climate, and the magazine of Europe." Thoſe plants which thrive between the tropics may be cultivated in the ſouth of France; and thoſe which are the produce of northern climates, may be cultivated in the northern departments; by which means, France will be in poſſeſſion of all foreign plants and drugs, without the exportation of ſpecie.

2*d*, The National Bibliography was decreed in the ſitting of 22d *Germinal*, in the ſecond year. It conſiſts of a complete catalogue of books of all deſcriptions, the property of the nation; it was then aſcertained, that the republic poſſeſſed more than ten millions of books. The titles of them were to be adjuſted by actual compariſons; the manuſcripts to be regiſtered ſeparately; anonymous productions were to be arranged according to their ſubjects; and thoſe of known authors in the alphabetical order of the names. The ſeveral editions to be claſſed according to their dates: and what may be deemed more important, this French National Bibliography will contain a dictionary of anonymous books, as well as thoſe publiſhed under fictitious names, a deſideratum in the republic of letters.

3*d*, The annihilation of all *patois*, or dialects, decreed in the ſitting of the 16th *Prairial*, in the ſecond year. Notwithſtanding the univerſality of the French language, and that it was excluſively ſpoken in the majority of the inland departments, yet there exiſted thirty various dialects in France. It is more aſtoniſhing that Rozier had remarked, that between one neighbouring village and another, there was ſo conſiderable a difference in the dialect, that the inhabitants could not underſtand each other; and the vineſtock had thirty different names. The naturaliſt, Villars, has ſtated, that in the nomenclature of vegetables, in the departments, he had only met with an hundred which had a common appellation.

4th, The eſtabliſhment of the *Conſervatoire des Arts et Métiers*, was decreed in the ſitting of the 8th of *Vendemiaire*, in the third year. This conſiſts of a ſpacious hall, in the form of an amphitheatre, and contains the inſtruments and the models of machinery connected with the arts, and a deſcription of their uſes, with every book relating to them. Annexed to this eſtabliſhment are three expoſitors and a draughtſman, who explain to the ſtudents the uſe of each inſtrument, and who regiſter every new diſcovery, which is preſented to the *Bureau de Conſultation*, to the lyceum of arts, the *ci-devant* academy of ſciences, or to the board of commerce.

5th, The eſtabliſhment of the board of longitude was decreed in the ſitting of the 7th of *Meſſidor*, third year. It was certainly a diſgrace under the monarchy, that an aſtronomical and nautical eſtabliſhment, which had already proved ſo beneficial to Great Britain, ſhould not have been adopted in France. In conſequence of this decree, the French board is now as complete as the Engliſh. It conſiſts of ten members, and has under its juriſdiction the national obſervatory at Paris, and all the aſtronomical inſtruments belonging to the republic. It correſponds with foreign aſtronomers; delivers public lectures on aſtronomy and navigation; and its proceedings are annually recited in a public ſitting.

6th, The general ſchool of the Oriental languages was eſtabliſhed by a decree of the 10th of *Germinal*, in the fourth year. This ſchool adjoins to the national library, and all the books and manuſcripts relative to Oriental literature are depoſited in it.

7th, The national muſeum of antiquities was decreed in the ſitting of 20th of *Prairial*, fourth year. A ſchool of this deſcription was ſucceſsfully eſtabliſhed at Vienna, by Eckel; at Gottingen, by Heyne; at Leipſick, by Erneſt; and even at Straſburgh, by the celebrated Obeilin: Paris was, however, without one. This national archeology, or ſcience of antiquity, is divided into nine different claſſes: inſcriptions, characters, ſtatues, *bas reliefs*, ſculptures, paintings, moſaics, medals, civil, religious, and military inſtruments. This extenſive eſtabliſhment is under the direction of two principal profeſſors; *le Conſervateur Profeſſeur, et le Conſervateur Bibliothecaire*. The province of the former is to deliver public lectures on the ſeveral branches of antiquities, to teach the theory of medals and engravings, the hiſtory of the arts among the ancients, &c. The duties of the latter are merely of a bibliographical nature.

8th, The new modelling of the Grand National Library, was decreed in the ſitting of 25th *Vendemiaire*, in the fourth year. By virtue of this decree, the place of librarian in chief was ſuppreſſed, and the whole eſtabliſhment placed under a *conſervatoire* of eight members; of whom two were appointed for the ſuperintendance of printed books; two for manuſcripts; two for antiquities; and two for engravings. From theſe a temporary director is annually choſen, who ſuperintends the whole acts occaſionally as preſident of this aſſembly, and maintains a regular correſpondence with the conſtituted authorities relative to the concerns of the library.

9th, The augmentation of the Muſeum of Natural Hiſtory, formerly called *Le Jardin Royal des Plantes*. This eſtabliſhment was decreed the 15th *Brumaire*, third year, upon a report of Thibadeau, in the name of the committee of Public Inſtruction. Beſides the addition of large rooms, and various other buildings, there are new collections of natural curioſities and productions; and the library is much increaſed. It is open to the public three times a week. At ſtated periods all the naturaliſts in Paris deliver courſes of lectures in the various branches of natural hiſtory. The muſeum is ſaid to have received greater improvements from this augmentation than from all the labours of Buffon, or from its foundation, ſince the time of Tournefort.

10th, The *Ecole des Mines* was eſtabliſhed in the *Hotel des Monnaies*, and has for its direction the naturaliſt Le Sage. This inſtitution is unrivalled in Europe; and the collection of mineralogical curioſities ſurpaſſes whatever can be conceived.

11th, The ſociety of natural hiſtory in Paris, deſervedly claſſes among thoſe which have rendered the greateſt ſervices to the cauſe of ſcience ſince the revolution. A lecture of public inſtruction is held every ten days, which is generally given by one of the members, and which is open to all the lovers of natural hiſtory. Premiums are propoſed for diſſertations; one of which, by the late C. Herman, jun. (whoſe early deceaſe was a great loſs to the republic of letters) on the *apterous* claſs of inſects, may be ſaid to conſtitute an epocha in the annals of natural hiſtory. The ſociety has publiſhed a volume of memoirs, in folio, entitled, "*Tranſactions of the Society of Natural Hiſtory.*" It has likewiſe erected a ſtatue to the great Linnæus, in the national garden of plants; and, at the period when every public inſtruction was ſuſpended, gave lectures on the different branches of ſcience belonging to its department. Several intelligent and ſkilful navigators, among others thoſe ſent in ſearch of the unfortunate La Pérouſe, as well as thoſe which accompanied Buonaparte on his romantic expedition to Egypt, were members of this ſociety.

This ſtatement of facts relative to the preſent ſtate of public inſtruction, the ſciences, the arts, and the progreſs of national literature in France, has been taken from a miſcellany, of which the principal writers are well acquainted with what is doing in that diſtracted country. They call it a ſublime ſyſtem; and ſeem to conſider the increaſe of the national library, the improvement of the botanic gardens, and the diſcoveries that have been made by the different ſchools or inſtitutes, as furniſhing a demonſtration that the republican government is more favourable to the advancement of ſcience, than the monarchical, whether abſolute or limited. But it ſhould not be forgotten, that this ſyſtem is yet in its infancy; and that in proſecuting new ſchemes, all men, and more eſpecially Frenchmen, are actuated by an enthuſiaſm which gradually cools as their purſuits become familiar. We ſhall therefore venture to predict, that the different ſchools will not diſplay ſuch ardour ſeven years hence as they do at preſent; and that if the republican government continue a dozen of years in France, the progreſs of ſcience in that country will not be more rapid than it was under the monarchy. We muſt remember, too, that the French libraries, muſeums, and picture galleries, have been improved by means which the morals of other governments do not employ—by rapine and robbery.

That ſomething may be learned from this ſyſtem to improve the modes of education in other countries, we admit; and it is for that reaſon that we have inſerted an account of it. But if it contains ſomething worthy of imitation, it contains likewiſe much to be ſhunned. We do not think it conſiſtent with the *rights of man* to *compel* parents to ſend their children to be educated in *particular* ſchools; eſpecially in ſchools where not only religious inſtruction is omitted, but where, there is reaſon to believe, that the profeſſors are at pains to raze all religious impreſſions from the youthful mind. In a nation denying the truth of Chriſtianity, it is not to be ſuppoſed that the Chriſtian religion will be publicly taught; but in a nation of philoſophers, as the French call themſelves, it might have been expected that the laws of religious toleration would have been ſo far regarded, that Chriſtian parents would not have been *compelled* to ſend their children to *antichriſtian* ſchools! But it is not Chriſtianity alone that is neglected in this *ſublime* ſyſtem of education. Though the legiſlative body has ſome time ago decreed that there is a God, there is not in any one of thoſe ſchools the ſmalleſt care taken to inſtruct the republican youth in the principles even of natural religion! We might indeed have looked for it under the title *Metaphyſics*, had not the conſtitution of the National Inſtitute taught us, that French metaphyſics attend to nothing but the analyſis of ſenſations and ideas. Yet the legiſlators might have liſtened on this ſubject to a republican as ſound as themſelves, and who was likewiſe no friend to ſuperſtition. "Nam et Majorum inſtituta tueri ſacris, ceremoniiſque retinendis ſapientis eſt. Non ſolum ad religionem pertinet, ſed etiam ad *civitatis* ſtatum, ut ſine iis, qui ſacris publice præſunt, religioni privatæ ſatisfacere non poſſint." *Cicero de Nat. Deorum.*

INSURANCE, in law and commerce, though an excellent inſtitution, is not of high antiquity. The oldeſt laws and regulations concerning inſurance, with which the indefatigable Beckmann is acquainted, are the following:

On the 28th of January 1523, five perſons appointed for that purpoſe drew up at Florence ſome articles which are ſtill employed on the exchange at Leghorn. Theſe important regulations, together with the preſcribed form of policies, which may be conſidered as the oldeſt, have been inſerted, in Italian and German, by Magens, in his Treatiſe on Inſurance, average, and bottomry, publiſhed at Hamburgh in 1753.

There is ſtill preſerved a ſhort regulation of the 25th May 1537, by the Emperor Charles V. reſpecting bills of exchange and inſurance, in which the ſtrictly fulfilling only of an agreement of inſurance is commanded.

In the year 1556, Philip II. king of Spain, gave to the Spaniſh merchants certain regulations reſpecting inſurance, which are inſerted by Magens, with a German tranſlation, in his work before-mentioned. They contain ſome forms of policies on ſhips going to the Indies.

In the year 1598, the *Kamer von aſſurantie*, chamber of inſurance, was eſtabliſhed at Amſterdam. An account of the firſt regulations of this inſurance office may be ſeen in Pontanus's Hiſtory of the city of Amſterdam, and in other works.

In the year 1600, regulations reſpecting inſurance were formed by the city of Middelburg in Zealand.

It appears that the firſt regulations reſpecting inſurances in England, which may be ſeen in *Anderſon's Hiſtory of Commerce*, were made in the year 1601. We find by them, that inſurers had before that period conducted themſelves in ſuch a manner, that the utmoſt confidence was repoſed in their honeſty, and that on this account few or no diſputes had ariſen.

Of the various policies for inſurance in England, a pretty accurate account will be found in the *Encyclopædia*; but there is one of them, of which our account muſt be acknowledged to be now defective. This is,

INSURANCE on lives; which is a policy that has greatly increaſed, in conſequence of its utility being more generally underſtood. Of the two offices for life-aſſurances, noticed in that article, the former, entitled the *Amicable Society*, has extended the number of its ſhares to 4000; but, as we have already obſerved, the nature of the inſtitution is too limited to become of general importance. The latter, entitled, the *Society for Equitable Aſſurances on Lives and Survivorſhip*, is undoubtedly one of the moſt important inſtitutions of the kind, as will appear by the following account, with which we have been favoured by an obliging correſpondent, and upon the accuracy of which our readers may depend:

The members of the equitable ſociety, finding, in June 1777, that their affairs were in a flouriſhing ſituation, reſolved to reduce their annual premiums one tenth; and in 1782, adopted new tables agreeable to the probabilities of life at Northampton, in lieu of thoſe they had hitherto uſed, formed from the London bills of mortality. But though it was evident, that the new tables were much better adapted for aſſuring promiſcuouſly perſons reſiding in the country, or in large towns, it was thought proper, for greater ſecurity, to make an addition of 15 per cent. to the real value of the aſſurances, as computed from the table of mortality at Northampton; and with the view of making an adequate compenſation to the aſſured for their former payments, which had been ſo much higher than would be required by the new rates, an addition was made to their claims of L.1 : 10s. per cent. for every premium they had paid. The conſequence of theſe meaſures proved highly favourable to the ſociety; for its buſineſs increaſed ſo faſt, that in 1785 it was nearly doubled; the ſums aſſured amounting to upwards of L.720,000. At this period, the favourable reſult of a minute and very laborious inveſtigation of the ſtate of the ſociety, induced them to take off the 15 per cent. charged upon the premiums in 1782, and make a further addition to the claims of L.1 per cent. for every payment made prior to the 1ſt January 1786. A ſtill greater increaſe of ſucceſsful buſineſs determined them, in 1791, to make another addition of L.1 per cent. to the claims; and in the following year, a further addition of L.2 per cent.; by which the claims upon aſſurances of the year 1770 were more than doubled; and thoſe of an earlier date increaſed in a ſtill higher proportion. By theſe advantages to its members, and the honourable and truly equitable manner in which the concerns of the ſociety are tranſacted, the augmentation of their buſineſs has been ſo great, that on the 31ſt December 1792, the ſums aſſured (without including the additions made to them) amounted to upwards of L.3,000,000; and on the 31ſt December 1795, to about L.4,000,000.

The rates of aſſurance, as reduced to their real values in 1786, and according to which the ſociety now tranſact buſineſs, are as follows:

Sum Aſſured £. 100.

Age.	*One Year.*			*Seven Years.*			*Whole Life.*		
15	£. 0	17	11	£. 1	2	11	£. 1	18	7
20	1	7	3	1	9	5	2	3	7
25	1	10	7	1	12	1	2	8	1
30	1	13	3	1	14	11	2	13	4
35	1	16	4	1	18	10	2	19	10
40	2	0	8	2	4	1	3	7	11
45	2	6	8	2	10	10	3	17	11
50	2	15	1	3	0	8	4	10	10
55	3	5	0	3	12	0	5	6	4
60	3	18	1	4	7	1	6	7	4
65	4	15	2	5	10	10	7	16	9

The other offices in London for the aſſurance of lives are, the *Royal Exchange Aſſurance*, the *Weſtminſter Society*, and the *Pelican Life Office*.

The corporation of the *Royal Exchange Aſſurance* was empowered to aſſure lives by its ſecond charter, dated 29th April 1721; but the original object of the company being ſea aſſurances, and the true principles of aſſuring on lives being at that time little underſtood, this branch of their buſineſs was at firſt comparatively ſmall: they generally required a premium of five or ſix guineas per cent. without any regard to the age; and the aſſurance, which was uſually for a ſmall ſum, was ſeldom for a greater term than one year. In this manner they continued to aſſure upon lives till the end of the year 1783, when the increaſing importance of this part of their buſineſs, which they had ſome years felt, induced them to adopt a regular table of rates of aſſurance, according to the Northampton regiſters of mortality, but with a greater addition to the real values than had been made by the "Society for Equitable Aſſurances on Lives and Survivorſhip." This was thought proper, from the conſideration that the aſſurers with the Royal Exchange company are not in any caſe liable to a call upon them beyond the premium they engage to pay, and have the ſecurity of the capital and funds of the company ariſing from the other branches of their buſineſs; however, the company, finding themſelves ſucceſsful in their life aſſurances, determined, in 1790, to reduce their premiums; and in 1797 made a ſtill greater reduction, by which they are brought very near to thoſe above ſtated. This company have agents in all the principal towns of Great Britain, and are impowered to aſſure lives in all parts of the world.

The *Weſtminſter Society* was eſtabliſhed in 1792, for aſſuring lives, and granting annuities. Their terms are nearly the ſame as thoſe of the Royal Exchange Aſſurance; but not being a corporate body, every perſon aſſuring ſigns a declaration, that he accepts the joint ſtock of the ſociety as his ſecurity.

The *Pelican Life Office* was inſtituted in 1797, by ſome of the principal proprietors of the Phœnix Fire Office. The rates which they have publiſhed vary conſiderably from thoſe of the other offices; but whether they are founded on more juſt principles, time and experience muſt determine. This ſociety alſo makes a new ſpecies of aſſurance, by way of endowment for daughters, or for children generally, when they ſhall attain the age of twenty-one years.

INTEGRAL CALCULUS, in the new analyſis, is the reverſe of the differential calculus, and is the finding of the integral from a given differential; being ſimilar to the inverſe method of fluxions, or the finding the fluent to a given fluxion. See FLUXIONS, *Encycl.*

INTEREST, is the allowance given for the uſe of money by the borrower to the lender, and is either *ſimple* or *compound*. The method of computing both intereſts is explained in the article ALGEBRA, (*Encycl.*) page 427, &c.; and the ſubject of ſimple intereſt is again reſumed in ARITHMETIC, (*Encycl.*) n° 20. The application of the canons for the computation of compound intereſt, to the value of annuities, the only caſe in which that intereſt is allowed by the laws of this country, may be ſeen in the articles ANNUITY and SURVIVORSHIP, (*Encycl.*); where various tables are given to facilitate the different computations. Some of our readers, however, have expreſſed a wiſh to have the rule for computing compound intereſt ſo ſtated, as to be underſtood by thoſe who are unacquainted with algebraic ſymbols. Their wiſh may be eaſily gratified.

The general formula $S = p R^t$ anſwers for the amount of any ſum, whether the intereſt be payable yearly, half-yearly, quarterly, or daily. Let R denote the amount of one pound for the firſt payment, and t the number of payments, the unit being from the commencement till the firſt payment is due; alſo, let l denote the logarithm of any quantity before which it is wrote; then, from the known property of logarithms, the theorem may be expreſſed thus, $l.\,S = l.\,p + l.\,R \times t$.

Required the amount of L. 250 at 5 per cent. compound intereſt, for 12 years, reckoning the intereſt payable yearly, half-yearly, quarterly, and daily?

Yearly. $p = 250$, $R = 1{\cdot}05$, $t = 12$.

$0{\cdot}0211893 = l.\,R$
12

$\cdot 2542716 = l.\,R \times t.$
$2{\cdot}3979400 = l.\,p.$

$l.\,S = 2{\cdot}6522116$ — L. $448 : 19 : 3\frac{1}{4}$ = Amount.
250

$198 : 19 : 3\frac{1}{4}$ = Comp. intereſt.

Half yearly, $p = 250$, $R = 1{\cdot}025$, $t = 24$.

$0{\cdot}0107239 = l.\,R.$
24

428956
214478

$\cdot 2573736 = l.\,R \times t.$
$2{\cdot}3979400 = l.\,p.$

$l.\,S = 2{\cdot}6553136$ — L. $452 : 3 : 7\frac{1}{4}$ = Amount.
250

$202 : 3 : 7\frac{1}{4}$ = Intereſt.

Quarterly.

Intereſt, Interpolation.

Quarterly. $p = 250$, $R = 1{\cdot}0125$, $t = 48$.

$$\begin{array}{rl} 0{\cdot}0053950 & = l.\ R. \\ 48 & \\ \hline 431600 & \\ 215800 & \\ \hline {\cdot}2589600 & = l.\ R \times t. \\ 2{\cdot}3979400 & = l.\ p. \\ \hline \end{array}$$

$$l.\ S = 2{\cdot}6569000 — L.\ 453 : 16 : 8\tfrac{1}{4} = \text{Amount.}$$

$$\begin{array}{r} 250 \\ \hline 203 : 16 : 8\tfrac{1}{4} = \text{Intereſt.} \end{array}$$

Daily, $p = 250$, $R = 1 + \frac{{\cdot}05}{365} = \frac{365{\cdot}05}{365}$, $t = 365 \times 12$.

$$\begin{array}{rl} 2{\cdot}5623524 & \\ 2{\cdot}5622929 & \\ \hline {\cdot}0000595 & = l.\ R. \\ 4380 & \\ \hline 47600 & \\ 1785 & \\ 2380 & \\ \hline {\cdot}2606100 & = l.\ R \times t. \\ 2{\cdot}3979400 & = l.\ p. \\ \hline \end{array}$$

$$l.\ S = 2{\cdot}6585500 — L.\ 455 : 11 : 3\tfrac{1}{2} = \text{Amount.}$$

$$\begin{array}{r} 250 \\ \hline 205 : 11 : 3\tfrac{1}{2} = \text{Intereſt.} \end{array}$$

INTERPOLATION, in the modern algebra, is uſed for finding an intermediate term of a ſeries, its place in the ſeries being given. See ALGEBRA and SERIES, *Encycl.*

The method of interpolation was firſt invented by Mr Briggs, and applied by him to the calculation of logarithms, &c. in his Arithmetica Logarithmica, and his Trigonometria Britannica; where he explains, and fully applies, the method of interpolation by differences. His principles were followed by Reginal and Mouton in France, and by Cotes and others in England. Wallis made uſe of the method of interpolation in various parts of his works; as his arithmetic of infinites, and his algebra, for quadratures, &c. The ſame was alſo happily applied by Newton in various ways: by it he inveſtigated his binomial theorem, and quadratures of the circle, ellipſe, and hyperbola. See Wallis's Algebra, chap. 85. &c. Newton alſo, in lemma 5. lib. 3. Princip. gave a moſt elegant ſolution of the problem for drawing a curve line through the extremities of any number of given ordinates; and in the ſubſequent propoſition, applied the ſolution of this problem to that of finding, from certain obſerved places of a comet, its place at any given intermediate time. And Dr Waring, who adds, that a ſolution ſtill more elegant, on ſome accounts, has been ſince diſcovered by Meſſ. Nichol and Stirling, has alſo reſolved the ſame problem, and rendered it more general, without having recourſe to finding the ſucceſſive differences. *Philoſ. Tranſ.* vol. 69. part 1. art. 7.

Interſcendent ‖ Involution.

INTERSCENDENT, in algebra, is applied to quantities, when the exponents of their powers are radical quantities. Thus $x^{\sqrt{2}}$, $x^{\sqrt{a}}$, &c. are interſcendent quantities.

INTERSTELLAR, a word uſed by ſome authors to expreſs thoſe parts of the univerſe that are without and beyond the limits of our ſolar ſyſtem.

INTRADOS, the interior and lower ſide, or curve, of the arch of a bridge, &c. In contradiſtinction from the extrados, or exterior curve, or line on the upper ſide of the arch. See ARCH in this *Suppl.*

INVOLUTION and EVOLUTION, are terms introduced into geometry by the celebrated Mr Huyghens, to expreſs a particular manner of deſcribing curvilineal ſpaces which occurred to him when occupied in the improvement of his noble invention of pendulum clocks. Although he was even aſtoniſhed at the accuracy of their motion, and they ſoon ſuperſeded all balance clocks, he knew that the wide vibrations were ſomewhat ſlower than the narrow ones, and that a circle was not ſufficiently incurvated at the ſides to render all the vibrations iſochronous. The proper curve for this purpoſe became an intereſting object. By a moſt accurate inveſtigation of the motions of heavy bodies in curved paths, he diſcovered that the cycloid was the line required. Lord Brouncker had diſcovered the ſame thing, as alſo Dr Wallis. But we do not imagine that Huyghens knew of this; at any rate, he has the full claim to the diſcovery of the way of making a pendulum oſcillate in a cycloidal arch. It eaſily occurred to him, that if the thread by which the pendulum hangs be ſuſpended between two curved cheeks, it would alternately lap on each of them in its vibrations, and would thus be raiſed out of the circle which it deſcribes when ſuſpended from a point. But the difficulty was to find the proper form of thoſe cheeks. Mr Huyghens was a moſt excellent geometer, and was poſſeſſed of methods unknown to others, by which he got over almoſt every difficulty. In the preſent caſe there was fortunately no difficulty, the means of ſolution offering themſelves almoſt without thought. He almoſt immediately diſcovered that the curve in queſtion was the ſame cycloid. That is, he found, that while a thread unwinds from an arch of a cycloid, beginning at the vertex, its extremity deſcribes the complementary arch of an equal cycloid.

Thus he added to this curve, already ſo remarkable for its geometrical properties, another no leſs curious, and infinitely exceeding all the others in importance.

The ſteps by which this property was diſcovered are ſuch direct emanations from general principles, that they immediately excited the mind of Mr Huyghens, which delighted in geometry, to proſecute this method of deſcribing or transforming curve lines by evolution. It is ſurpriſing that it had not ere this time occurred to the ancient geometers of the laſt century, and particularly to Dr Barrow, who ſeems to have racked his fancy for almoſt every kind of motion by which curve lines can be generated. Evolution of a thread from a curve is a much more obvious and conceivable geneſis than that of the cycloid invented by Merſennus, or that of the conchoid by Nicomedes, or thoſe of the conic ſections by Vieta. But except ſome vague expreſſions by Ptolemy and Gaſſendus, about deſcribing ſpirals by a thread unlapped from a cylinder, we do not recollect any thing of the kind among the writings of the mathematicians; and it is to Huyghens alone that we are indebted for this very beautiful and important branch of geometry. It well deſerves both of theſe epithets. The theorems which conſtitute the doctrines of evolution are remarkable for their perſpicuity and neatneſs. Nothing has ſo much contributed to give us clear notions of a very delicate ſubject of mathematical diſcuſſion, namely curvature, and the meaſure and variations of curvature. It had become the ſubject of very keen debate; and the notions entertained of it were by no means diſtinct. But nothing can give ſuch a preciſe conception of the difference of curvature, in the different parts of a cycloid or other curve, as the beholding its deſcription by a radius continually varying in length. This doctrine is peculiarly valuable to the ſpeculator in the higher mechanics. The intenſity of a deflecting force is eſtimated by the curvature which it induces on any rectilineal motion; and the variations of this intenſity, which is the characteriſtic of the force, or what we call its nature, is inferred from the variations of this curvature. The evolution and involution of curve lines have therefore great claim to our attention. But a Work like ours can only propoſe to exhibit an outline of the ſubject; and we muſt refer our readers to thoſe eminent authors who have treated it in detail. Varignon, in the Memoirs of the French Academy for 1706, has been at immenſe pains to preſent it in every form; James Bernoulli has alſo treated the ſubject in a very general and ſyſtematic manner. Some account is given of it in every treatiſe of fluxions. We recommend the original work of Mr Huyghens in particular; and do not heſitate to ſay, that it is the fineſt ſpecimen (of its extent) of phyſico-mathematical diſcuſſion that ever has appeared. Huyghens was the moſt elegant of all modern geometers; and both in the geometrical and phyſical part of this work, *De Horologio Oſcillatorio*, he has preſerved the utmoſt rigour of demonſtration, without taking one ſtep in which Euclid or Apollonius would not have followed him.

> ———— *juvat integros accedere fontes*
> *Atque haurire.*

Such authors form the taſte of the young mathematician, and help to preſerve him from the almoſt mechanical procedure of the expert ſymbolical analyſt, who arrives at his concluſion without knowing how he gets thither, or having any notions at all of the magnitudes of which he is treating.

There are two principal problems in this doctrine.

I. To aſcertain the nature of the figure generated by the evolution of a given curve.

II. To determine the nature of the curve by whoſe evolution a given curve may be generated.—We ſhall conſider each of theſe in order, and then take the opportunity which this ſubject gives of explaining a little the abſtruſe nature of curvature, and its meaſures and variations, and take notice of the opinions of mathematicians about the preciſe nature of the angle of contact.

Plate XXXI.

The curve line ABCDEF (fig. 1.) may be conſidered as the edge of a crooked ruler or mould; a thread may be ſuppoſed attached to it at F, and then lapped along it from F to A. If the thread be now led away from A, keeping it always tight, it is plain that the extremity A muſt deſcribe a curve line $A b c d e f$, and that the detached parts of the thread will always be tangents to the curve ABCDEF. In like manner will the curve line $F d' c' b' A'$ be deſcribed by keeping the thread faſt at A, and unlapping it from the other end of the mould.

This proceſs was called by Mr Huyghens the Evolution of the curve ADF. ADF is called the Evolute. $A d f$ was named by him the Curve by Evolution. It has been ſince more briefly termed the Evolutrix, or unlapper. It has alſo been called the Involute; becauſe, by performing the proceſs in the oppoſite direction $f d A$, the thread is lapped up on the mould, and the whole ſpace $ADF f d A$ is folded up like a fan. The detached parts $C c$, $D d$, or $C c'$, $D d'$, &c. of the thread, are called Radii of the Evolute; perhaps with ſome impropriety, becauſe they rather reſemble the momentary radii of the evolutrix. We may name them the evolved radii. The beginning A of evolution may be conſidered as the vertex of the curves, and the ends F and f may be called the terms.

There is another way in which this deſcription of curve lines may be conceived. Inſtead of a thread $F f$ gradually lapped up on the mould, we may conceive $F f$ to be a ſtraight edged ruler applied to the mould, and gradually rolled along it without ſliding, ſo as to touch it in ſucceſſion in all its points. It is evident, that by this proceſs the point f will deſcribe the curve $f d A$, while the point F deſcribes the other curve $F d a$. This way of conceiving it gives a great extenſion to the doctrine, and homologates it with that geneſis of curve lines by which cycloids of all kinds are deſcribed, and which we may diſtinguiſh by the name of Provolution. For it is plain, that the relative motions of the points A and b are the ſame, whether the ruler $b B b'$ roll on the mould ABF, or the mould roll on the ruler: but there will be a great difference in the form of the line traced by the deſcribing point, if we ſuppoſe the plane on which it is traced to be attached to the rolling figure. Thus, when a circle rolls on a ſtraight line, a point in its circumference traces a cycloid on the plane attached to the ſtraight line, while the point of the ſtraight line which quitted the circle deſcribes on the plane attached to the circle another line; namely, the involute of the circle. This mode of deſcription allows us to employ a curved ruler in place of the ſtraight one $b B b'$; and thus gives a vaſt extenſion to the theory. But at preſent we ſhall confine ourſelves to the employment of the ſtraight line $b B b'$, only keeping in mind, that there is an intimate connection between the lines of evolution and of provolution.

By the deſcription now given of this proceſs of evolution and involution, it is plain,

1. That the evolution is always made from the convex ſide of the evolute.

2. That the evolved radii $B b$, $C c$, $D d$, &c. are reſpectively equal to the arches BA, CA, DA, &c. of the evolute which they have quitted; and that $b B b'$, $c C c'$, $d D d'$, &c. are always equal to the whole arch ADF.

3. That any point B of the lapped up thread deſcribes during its evolution a curve line $B \gamma \delta \epsilon \varphi$ parallel to $b c d e f$; becauſe theſe curves are always equidiſtant from each other.

4. That if the thread extend beyond the mould as a tangent to it, the extremity α will deſcribe a parallel or

equidiſtant curve $\alpha\beta\gamma\delta\epsilon\varphi$, lying without A$bcdef$. From this it appears that B$\gamma\delta\epsilon\varphi$ is the complete evolutrix of FEDCB, while $bdcef$ is the evolutrix of that arch, and the added tangent Bb. In like manner, the lapped up thread ADF, with the added part Fφ', deſcribes the evolutrix $\varphi'\epsilon'\delta'\gamma'\beta'$ A'.

5. If from any point C of the evolute there be drawn lines Cb, Cc, Cd, Ce, &c. to the evolutrix, thoſe which are more remote from the vertex are greater than thoſe which are nearer. Draw Bb, cC, dD, eE, touching the evolute. Cb is leſs than CB + Bb; that is (2), than Cc. Again, DC + Cc is equal to Dd, which is leſs than DC + Cd. Therefore Cc is leſs than Cd. Now let Ce cut Dd in r. Then er + rDE is greater than eE. But eE is equal to dr + rDE. Therefore er is greater than dr; and er + rC is greater than dr + rC, which is greater than cC. Therefore eC is greater than cC.

6. Hence it follows, that a circle deſcribed round any point of the evolute, with a radius reaching to any point of the evolutrix, will cut the evolutrix in that point, and be wholly within it on the ſide remote from the vertex, and without it on the ſide next the vertex.

7. The evolved radius cuts every arch of the evolutrix perpendicularly, or a right line drawn through the interſection at right angles touches the evolutrix in that point. Through any point d draw the line mdt at right angles to dD. The part of it md next to the vertex is wholly without the curve, becauſe it is without the circle deſcribed round the centre D; and this circle is without the evolutrix on that ſide of d which is next the vertex (6). Any point t on the other ſide of d is alſo without the curve. For let teE be another evolved radius, cutting Dd in n: then nd is leſs than nt, becauſe ndt is a right angle by conſtruction; and therefore ntd is acute. But becauſe En + nD are greater than ED, En + nd are greater than ED + Dd, that is, than Ee, and nd is greater than ne. Therefore, ſince it is leſs than nt, it follows that ne is much leſs than nt, and t lies without the curve. Therefore the whole line mdt is without the curve, except in the point d. It therefore touches the curve in d, and the radius Dd cuts it at right angles in that point. By the ſame reaſoning, it is demonſtrated, that all the curves Abdf, $\alpha\beta\delta\varphi$, A'$b'd'f'$, $\alpha'\beta'\delta'\varphi'$, are cut perpendicularly by the tangents to the evolute. Alſo all theſe curves interſect the evolute at right angles in their vertexes.

It follows from this propoſition, that from every point, ſuch as s, or i, or o, &c. in the ſpace AOF comprehended by the evolute and its extreme tangents AO, FO, two perpendiculars may be drawn to the evolutrix Adf; and that from any point in the ſpace within the angle Aof only one perpendicular can be drawn; and that no perpendicular can be drawn from any point on the other ſide of ADF. Apollonius had obſerved theſe circumſtances in the conic ſections, but had not thought of marking the boundary formed by the evolute ADF. Had he noticed this, he would certainly have diſcovered the whole theory of evolution, and its importance in ſpeculative geometry.

It alſo follows from this propoſition, that if a curve A$bcdef$ is cut by the tangents of ABCDEF at right angles in every point, it will be deſcribed by the evolution of that curve: For if the evolutrix, whoſe vertex is A, be really deſcribed, it will coincide with Abcd in A, and have the ſame tangent; it therefore does not deviate from it, otherwiſe their tangents would ſeparate, and would not both be at right angles with the lines touching the evolute. They muſt therefore coincide throughout.

8. The arches bcd and $\beta\gamma\delta$, intercepted by the ſame radii Bb and Dd, may be called *concentric;* and the angles contained between the tangents drawn thro' their extremities are equal. Thus the angle $\lambda\pi o$ is equal to lpo: but although equidiſtant, parallel, and containing the ſame angle between their tangents and between their radii, they are not ſimilar. Thus, the arch $\alpha\beta$ has a curvature at α that is the ſame with that of any circle whoſe radius is equal to Aα; but the curvature at A is incomparable with it, and unmeaſurable. The ſame may be ſaid of the curvatures at β and at B.

9. If a circle udz be deſcribed round the centre D with the radius Dd, it both touches and cuts the evolutrix in the point d, and no circle can be deſcribed touching the curve in that point, and paſſing between it and the circle udz: For ſince it touches the curve in d, its centre muſt be ſomewhere in the line dD perpendicular to mdt. It cannot be in any point n more remote from d than D is; for it would paſs without the arch du, and be more remote than du from the arch dc of the evolutrix. On the other ſide, it would indeed paſs without the arch dz, which lies within the arch de of the evolutrix: but it would alſo paſs without the curve. For it has been already demonſtrated (7) that nd is greater than ne; and the curve would lie between it and the circle dz.

Thus it appears, that a circle deſcribed with the evolved radius approaches nearer to the curve, or touches it more cloſely, than any other circle; all other circles either interſect it in meaſurable angles, or are within or without the curve on both ſides of the point of contact. This circle udz has therefore the ſame curvature with the curve in the point of contact and coaleſcence. It is the EQUICURVE CIRCLE, the circle of equal curvature, the OSCULATING CIRCLE (a name given it by Leibnitz). The evolved radius of the evolute is the RADIUS OF CURVATURE of the evolutrix, and the point of the evolute is the CENTRE OF CURVATURE at the point of contact with the evolutrix. The evolute is the geometrical locus of all the centres of curvature of the evolutrix.

This is the moſt important circumſtance of the whole doctrine of the involution and evolution of curve lines. It is aſſumed as a ſelf-evident truth by the precipitant writers of elements. It is indeed very like truth: For the extremity of the thread is a momentary radius during the proceſs of evolution; and any minute arch of the evolute nearer the vertex muſt be conceived as more incurvated than the arch at the point of contact, becauſe deſcribed with ſhorter radii: for the ſame reaſon, all beyond the contact muſt be leſs incurvated, by reaſon of the greater radii. The curvature at the contact muſt be neither greater nor leſs than that of the circle. But we thought it better to follow the example of Huyghens, and to eſtabliſh this leading propoſition on the ſtricteſt geometrical reaſoning, acknowledging the ſingular obligation which mathematicians are under to him for giving them ſo palpable a method of fixing their notions on this ſubject. When the evolute of a curve is given, we have not only a clear view of the geneſis of the curve, with a neat and accurate mechanical method of deſcribing it, but alſo a diſtinct comprehenſion of the whole curvature, and a connected view of its gradual variations.

We ſpeak of curvature that is greater and leſſer; and every perſon has a general knowledge or conception of the difference, and will ſay, that an ellipſis is more curve at the extremities of the tranſverſe axis than any where elſe. But before we can inſtitute a compariſon between them with a preciſion that leads to any thing, we muſt agree about a meaſure of curvature, and ſay what it is we mean by a double or a triple curvature. Now there are two ways in which we may conſider curvature, or a want of rectitude: We may call that a double curvature which, in a given ſpace, carries us twice as far from the ſtraight line; or we may call that a double curvature by which we deviate twice as much from the ſame direction. Both of theſe meaſures have been adopted; and if we would rigidly adhere to them, there would be no room for complaint: but mathematicians have not been ſteady in this reſpect, and by mixing and confounding theſe meaſures, have frequently puzzled their readers. All agree, however, in their firſt and ſimple meaſures of curvature, and ſay, that the curvature of an arch of a circle is as the arch directly, and as the radius inverſely. This is plainly meaſuring curvature by the deflection from the firſt direction. In an arch of an inch long, there is twice as much deflection from the firſt direction when the radius of the circle is of half the length. If the radius is about 57$\frac{1}{4}$th inches, an arch of one inch in length produces a final direction one degree different from the firſt. If the radius is 114$\frac{1}{2}$ inches, the deviation is but half of a degree. The linear deflection from the ſtraight path is alſo one-half. In the caſe of circles, therefore, both meaſures agree: but in by far the greateſt number of caſes they may differ exceedingly, and the change of direction may be greateſt when the linear deviation is leaſt. Flexure, or change of direction, is, in general, the moſt ſenſible and the moſt important character of curvature, and is underſtood to be its criterion in all caſes. But our proceſſes for diſcovering its quantity are generally by firſt diſcovering the linear deviation; and, in many caſes, particularly in our philoſophical inquiries, this linear deviation is our principal object. Hence it has happened, that the mathematician has frequently ſtopped ſhort at this reſult, and has adapted his theorems chiefly to this determination. Theſe differences of object have cauſed great confuſion in the methods of conſidering curvature, and led to many diſputes about its nature, and about the angle of contact; to which diſputes there will be no end, till mathematicians have agreed in their manner of expreſſing the meaſures of curvature. At preſent we abide by the meaſure already given, and we mean to expreſs by curvature or flexure the change of direction.

This being premiſed, we obſerve, that the curvature of all theſe curves of evolution where they ſeparate from their evolutes, is incomparable with the curvature in any other place. In this point the radius has no magnitude; and therefore the curvature is ſaid to be infinitely great. On the other hand, if the evolved curve has an aſſymptote, the curvature of the evolutrix of the adjacent branch is ſaid to be infinitely ſmall. Theſe expreſſions becoming familiar, have occaſioned ſome very intricate queſtions and erroneous notions. There can be little doubt of their impropriety: For when we ſay, that the curvature at A is infinitely greater than at α, we do not recollect that the flexure of the whole arch A *b* is equal to that of the whole arch α β, and the flexure at A muſt either make a part of the whole flexure, or it muſt be ſomething diſparate.

The evolutrix A *b c d f* (fig. 2.) of the common equilateral hyperbola exhibits every poſſible magnitude of curvature in a very ſmall ſpace. At the vertex A of the hyperbola it is perpendicular to the curve; and therefore has the tranſverſe axis A φ A″ for its tangent. The curvature of the evolutrix at A is called infinitely great. As the thread unlaps from the branch ABC, its extremity deſcribes A *b c*. It is plain, that the evolutrix muſt cut the aſſymptote φ H at right angles in ſome point G, where the curvature will be what is called infinitely ſmall; becauſe the centre of curvature has removed to an infinite diſtance along the branch AF of the hyperbola. This evolutrix may be continued to the vertex of the hyperbola on the other ſide of the aſſymptote, by cauſing the thread to lap upon it, in the ſame way that Mr Huyghens completed his cycloidal oſcillation. Or we may form another evolutrix α β γ δ φ γ′ δ′ β′ A″, by lengthening the thread from G to φ, the centre of the hyperbola, and ſuppoſing that, as ſoon as the curve A δ φ is completed, by unlapping the thread from the branch ABC, another thread laps upon the hyperbola A″ F″. This laſt is conſidered as a more geometrical evolution than the other: For the mathematicians, extending the doctrine of evolution beyond Mr Huyghens's reſtriction to curves which had their convexity turned one way, have agreed to conſider as one continued evolution whatever will complete the curve expreſſed by one equation. Now the ſame equation expreſſes both the curves AF and A″F″, which occupy the ſame axis AA″. The cycloid employed by Huyghens is, in like manner, but one continuous curve, deſcribed by the continued provolution of the circle along the ſtraight line, although it appears as two branches of a *repeated* curve. We ſhall meet with many inſtances of this ſeemingly compounded evolution when treating of the ſecond queſtion.

Since the arch A *b d* G contains every magnitude of curvature, it appears that every kind of curvature may be produced by evolution. We can have no conception of a flexure that is greater than what we ſee at A, or leſs than what we ſee at G; yet there are caſes which ſeem to ſhew the contrary, and are familiarly ſaid, by the greateſt mathematicians, to exhibit curvatures infinitely ſmaller ſtill. Thus, let ABC (fig. 3.) be a conical parabola, whoſe parameter is AP. Let AEF be a cubical parabola, whoſe parameter is AQ. If we make AQ to AD as the cube of AP to the cube of AQ, the two parabolas will interſect each other in the ordinate DB. For, making AP = p, and AQ = q, and calling the ordinate of the conic parabola y, that of the cubic parabola z, and the indeterminate abſciſſa AD x, we have

$$p^3 : q^3 = q : x, = q^3 : z^3, \text{ and } p : q = q : z;$$

but $q : p = q : p$; therefore, by compoſition,

$$p^2 : q^2 = q^2 : px = q^2 : y^2, \text{ and } p : q = q : y;$$

therefore $z = y$, and the parabolas interſect in B.

Now, becauſe in all parabolas the ordinates drawn at the extremity of the parameters are equal to the parameters, the interſections q and p will be in a line Aqp, which makes half a right angle with the axis AP. Therefore, when AQ is greater than AP, the point q is without the conical parabola, and the whole arch of the cubical parabola cut off by the ordinate DB is alſo without it; but when AQ is leſs than AP, q is within the conical parabola, as is alſo the arch qB. Therefore the remaining arch BEA is without it, and is therefore leſs incurvated at A. An endleſs number of conical parabolas of ſmaller curvature may be drawn by enlarging AP; yet there will ſtill be an arch AEB of the cubical parabola which is without it, and therefore leſs incurvated. Therefore the curvature of a cubical parabola is leſs than that of any conical parabola: It is ſaid to be infinitely leſs, becauſe an infinity of cubical parabolas of *ſmaller curvature* than AEB may be drawn by enlarging AQ.

It may be demonſtrated in the ſame manner, that a paraboloid, whoſe ordinates are in the ſubbiquadrate ratio of the abſciſſæ, has an infinitely ſmaller curvature at the vertex than the cubical parabola. And the curvature of the paraboloid of the next degree is infinitely leſs than this; and ſo on continually. Nay, Sir Iſaac Newton, who firſt took notice of this remarkable circumſtance, demonſtrates the ſame thing of an endleſs ſucceſſion of paraboloids interpoſed between any two degrees of this ſeries. *Neque novit* (ſays he) *natura limitem.*

If this be the caſe, all curves cannot be deſcribed by evolution; for we have no conception of a radius of curvature that is greater than a line without limit. The theory of curvilineal motions delivered in the article DYNAMICS muſt be imperfect, or there muſt be curve lines which bodies cannot deſcribe by any powers of nature. The theory there delivered profeſſes to teach how a body can be made to deſcribe the cubical parabola, and many other curves which have theſe infiniteſimal curvatures; and yet its demonſtrations employ the radius of curvature, and cannot proceed without it. We profeſs ourſelves obliged to an attentive reader (who has not favoured us with his name) for making this obſervation. It merits attention.

There muſt be ſome paralogiſm or miſconception in all this language of the mathematicians. It does not neceſſarily follow from the arch AEB lying without the arch AIB, that it is leſs incurvated at A; it may be more incurvated between A and B. Accordingly we ſee, that the tangent BT of the conical parabola is leſs inclined to the common tangent AV than the tangent Bt of the cubical parabola is; and therefore the flexure of the whole arch AEB is greater than that of the whole arch AIB; and we ſhall ſee afterwards, that there is a part of AEB that is more incurvated than any part of AIB. There is nothing correſponding to this unmeaning and inconceivable ſucceſſion of ſerieſes of magnitudes of one kind, each of which contains an endleſs variety of individuals, and the greateſt of one ſeries infinitely leſs than the ſmalleſt of the next, &c.; there is nothing like this demonſtrated by all our arguments. In none of theſe do we ever treat of the curvature at A, but of a curvature which is *not* at A. At A we have none of the lines which are indiſpenſably neceſſary for the demonſtration. Beſides, in the very ſame manner that we can deſcribe a cubical parabola, and prove that it has an arch lying without the conical parabola, we can deſcribe a circle, and demonſtrate that it has alſo an arch lying without the parabola. Theſe infiniteſimal curvatures, therefore, are not warranted by our arguments, nor does it yet appear that there are curves which cannot be deſcribed by evolution. We are always puzzled when we ſpeak of infinites and infiniteſimals as of ſomething preciſe and determinate; whereas the very denomination precludes all determination. We take the diſtinguiſhing circumſtance of thoſe different orders for a thing clearly underſtood; for we build much on the diſtinction. We conceive the curvature of the cubical parabola as verging on that of the common parabola, and the one ſeries of curvatures as beginning where the other ends. But Newton has ſhewn, that between theſe two ſerieſes an endleſs number of ſimilar ſerieſes may be interpoſed. The very names given to the curvature at the extremities of the hyperbolic evolutrix have no conceptions annexed to them. At the vertex of the hyperbola there is no line, and at the interſection with the aſſymptote there is no curvature. Theſe unguarded expreſſions, therefore, ſhould not make us doubt whether all curves may be deſcribed by evolution. If a line be incurvated, it is not ſtraight. If ſo, two perpendiculars to it muſt diverge on one ſide, and muſt converge and meet on the other in ſome point. This point will lie between two other points, in which the two perpendiculars touch that curve by the evolution, of which the given arch of the curve may be deſcribed. Finally (which ſhould decide the queſtion), we ſhall ſee by and bye, that the cubic, and all higher orders of paraboloids, may be ſo deſcribed by evolution from curves having aſſymptotic branches of determinable forms.

Such are the general affections of lines generated by evolution. They are not, properly ſpeaking, peculiar properties; for the evolutrixes may be any curve lines whatever. They only ſerve to mark the mutual relations of the evolutes with their evolutrixes, and enable us to conſtruct the one, and to diſcover its properties by means of our knowledge of the other. We proceed to ſhew how the properties of the evolutrix may be determined by our knowledge of the evolute.

This problem will not long occupy attention, being much limited by the conditions. One of the firſt is, that the length of the thread evolved muſt be known in every poſition: Therefore the length of the evolved arch muſt, in like manner, be known; and this, not only *in toto*, but every portion of it. Now this is not univerſally, or even generally the caſe. The length of a circular, parabolic, hyperbolic, arch has not yet been determined by any finite equation, or geometrical conſtruction. Therefore their evolutrixes cannot be determined otherwiſe than by approximation, or by compariſon with other magnitudes equally undetermined. Yet it ſometimes happens, that a curve is diſcovered to evolve into another of known properties, although we have not previouſly diſcovered the length of the evolved arch. Such a diſcovery evidently brings along with it the rectification of the evolute. Of this we have an inſtance in the very evolution which gave occaſion to the whole of this doctrine; namely, that of the cycloid; which we ſhall therefore take as our firſt example.

Let ABC (fig. 5.) be a cycloid, of which AD is the axis, and AHD the generating circle, and AG a tangent to the cycloid at A, and equal to DC. Let

BKE touch the cycloid in B, and cut AG in K. It is required to find the ſituation of that point of the line BE which had unfolded from A?

Draw BH parallel to the baſe DC of the cycloid, cutting the generating circle in H, and join HA. Deſcribe a circle KEM equal to the generating circle AHD, touching AG in K, and cutting BK in ſome point E. It is known, by the properties of the cycloid, that BK is equal and parallel to HA, and that BH is equal to the arch A *b* H. Becauſe the circles AHD and KEM are equal, and the angles HAK and AKE are equal, the chords AH and KE cut off equal arches, and are themſelves equal. Becauſe BHAK is a parallelogram, AK is equal to HB; that is, to the arch A *b* H, that is, to the arch K *m* E. But if the circle KEM had been placed on A, and had rolled from A to K, the arch diſengaged would have been equal to AK, and the point which was in contact with A would now be in E, in the circumference of a cycloid AEF, equal to CBA, having the line AG, equal and parallel to DC, for its baſe, and GF, equal and parallel to DA, for its axis. And if the diameter KM be drawn, and EM be joined, EM touches the cycloid AEF.

Cor. The arch BA of the cycloid is equal to twice the parallel chord HA of the generating circle: For this arch is equal to the evolved line BKE; and it has been ſhewn, that EK is equal to KB, and BE is therefore equal to twice BK, or to twice HA. This property had indeed been demonſtrated before by Sir Chriſtopher Wren, quite independent of the doctrine of evolution; but it is given here as a legitimate reſult of this doctrine, and an example of the uſe which may be made of it. Whenever a curve can be evolved into another which is ſuſceptible of accurate determination, the arch of the evolved curve is determined in length; for it always makes a part of the thread whoſe extremity deſcribes the evolutrix, and its length is found, by taking from the whole length of the thread that part which only touches the curve at its vertex.

This geneſis of the cycloid AEF, by evolution of the cycloid ABC, alſo gives the moſt palpable and ſatisfactory determination of the area of the cycloid. For ſince BE is always parallel to AH, AH will ſweep over the whole ſurface of the ſemicircle AHD, while BE ſweeps over the whole ſpace CBAEF; and ſince BE is always double of the ſimultaneous AH, the ſpace CBAEF is quadruple of the ſemicircle AHD. But the ſpace deſcribed in any moment by BK is alſo one fourth part of that deſcribed by BE. Therefore the area GAEF is three times the ſemicircle AHD; and the ſpace DHABC is double of it; and the ſpace CBAG is equal to it.

Sir Iſaac Newton has extended this remarkable property of evolving into another curve of the ſame kind to the whole claſs of epicycloids, that is, cycloids formed by a point in the circumference of a circle, while the circle rolls on the circumference of another circle, either on the convex or concave ſide; and he has demonſtrated, that they alſo may all be rectified, and a ſpace aſſigned which is equal to their area (See *Principia*, B. I. prop. 48. &c.). He demonſtrates, that the whole arch is to four times the diameter of the generating circle as the radius of the baſe is to the ſum or difference of thoſe of the baſe and the generating circle. We recommend theſe propoſitions to the attention of the young reader who wiſhes to form a good taſte in mathematical reſearches; he will there ſee the geometrical principles of evolution elegantly exemplified.

We may juſt obſerve, before quitting this claſs of curves, that many writers, even of ſome eminence, in their compilations of elements, give a very faulty proof of the poſition of the tangent of a curve deſcribed by rolling. They ſay, for example, that the tangent of the cycloid at E is perpendicular to KE; becauſe the line KE is, at the moment of deſcription, turning round K as a momentary centre. This, to be ſure, greatly ſhortens inveſtigation; and the inference is a truth, not only when the rolling figure is a circle rolling on a ſtraight line, but even when any one figure rolls on another. Every point of the rolling figure really *begins* to move perpendicularly to the line joining it with the point of contact. But this geneſis of the arch E *e*, by the evolution of the arch B *b*, ſhews that K is by no means the centre of motion, nor HK the radius of curvature. Nor is it, in the caſe of epicycloids, trochoids, and many curves of this kind, a very eaſy matter to find the momentary centre. The circle KEM is both advancing and turning round its centre; and theſe two motions are equal, becauſe the circle does not ſlide but roll, the detached arch being always equal to the portion of the baſe which it quits. Therefore, drawing the tangents E *g*, M *g*, and completing the parallelogram E *f* M *g*, E *f* will repreſent the progreſſive motion of the centre, and E *g* the motion of rotation. EM, the motion compounded of theſe, muſt be perpendicular to the chord EK.

The inveſtigation that we have given of the evolutrix of the cycloid has been ſomewhat peculiar, being that which offered itſelf to Mr Huyghens at the time when he and many other eminent mathematicians were much occupied with the ſingular properties of this curve. It does not ſerve, however, ſo well for exemplifying the general proceſs. For this purpoſe, it is proper to avail ourſelves of all that we know of the cycloid, and particularly the equality of its arch BA to the double of the parallel chord HA. This being known, nothing can be more ſimple than the determination of the evolutrix, either by availing ourſelves of every property of the cycloid, or by adhering to the general proceſs of referring every point to an abſciſſa by means of perpendicular ordinates. In the firſt method, knowing that BE is double of BK, and therefore KE equal to HA, and KA = BH, = H *b* A, = K *m* E, we find E to be the deſcribing point of the circle, which has rolled from A to K. In the other method, we muſt draw EN perpendicular to AG; then, becauſe the point E moves, during evolution, at right angles to BE, EK is the normal to the curve deſcribed, and NK the ſubnormal, and is equal to the correſponding ordinate H′ I′ of the generating circle of the cycloid ABC. This being a characteriſtic property of a cycloid, E is a point in the circumference of a cycloid equal to the cycloid ABC.

Or, laſtly, in accommodation to caſes where we are ſuppoſed to know few of the properties of the evolute, or, at leaſt, not to attend to them, we may make uſe of the fluxionary equation of the evolute to obtain the fluxionary equation of the evolutrix. For this purpoſe, take a point *e* very near to E, and draw the evolving radius *b e*, cutting E *f* (drawn parallel to the baſe DC) in *o*; draw *e n* parallel to the axis of the evolute, cutting E o in v; alſo draw $b\,b\,i$ parallel to the baſe, and B d perpendicular to it. If both curves be now referred to the ſame axis CGF, it is plain that B b, B d, and $d\,b$ are ultimately as the fluxions of the arch, abſciſs, and ordinate of the evolute, and that E e, $e\,v$, and v E, are ultimately as the fluxions of the arch, abſciſſa, and ordinate of the evolutrix. Alſo the two fluxionary triangles are ſimilar, the ſides of the one being perpendicular, reſpectively, to thoſe of the other. If both are referred to one axis, or to parallel axes, the fluxion of the abſciſſa of the evolute is to that of its ordinate, as the fluxion of the ordinate of the evolutrix is to that of its abſciſſa. Thus, from the fluxionary equation of the one, that of the other may be obtained. In the preſent caſe, they may be referred to AD and FG, making CG equal to the cycloidal arch CBA. Call this a; AI, x; IB, y; and AB, or EB, z. In like manner, let F t be $= u$, t E $= v$, and FE $= w$; then, becauſe $\mathrm{DH}^2 = \mathrm{DA}^2 - \mathrm{AH}^2$, and DA and AH are the halves of CF and BE, we have $\mathrm{DH}^2 = \frac{a^2 - z^2}{4}$. Alſo $\mathrm{DI} = \frac{\mathrm{DH}^2}{\mathrm{DA}} = \frac{a^2 - z^2}{4 \times \frac{1}{2} a}, = \frac{a^2 - z^2}{2a}$. But DI = F t. Therefore F t, or u, $= \frac{a^2 - z^2}{2a}$. Alſo $\dot{w} = \frac{\dot{u}\,\dot{z}}{\dot{y}}$, by what was ſaid above, that is, $\dot{w} = \frac{a\,\dot{u}}{\sqrt{a^2 - z^2}}, = \frac{a\,\dot{u}}{\sqrt{2au}}$. Therefore we have $\dot{w} : \dot{u}\ (= a : \sqrt{2au}) = \sqrt{\tfrac{1}{2}a} : \sqrt{u} = \sqrt{\mathrm{GF}} : \sqrt{\mathrm{F}t}$, which is the analogy competent to a cycloid whoſe axis is GF = DA.

It is not neceſſary to inſiſt longer on this in this place; becauſe all theſe things will come more naturally before us when we are employed in deducing the evolute from its evolutrix.

When the ordinates of a curve converge to a centre, in which caſe it is called a radiated curve, it is moſt convenient to conſider its evolutrix in the ſame way, conceiving the ordinates of both as inſiſting on the circumference of a circle deſcribed round the ſame centre. Spirals evolve into other ſpirals, and exhibit ſeveral properties which afford agreeable occupation to the curious geometer. The equiangular, logarithmic, or loxodromic ſpiral, is a very remarkable example. Like the cycloid, it evolves into another equal and ſimilar equiangular ſpiral, and is itſelf the evolutrix of a third. This is evident on the ſlighteſt inſpection. Let C $r\,q\,p$ (fig. 6.) be an equiangular ſpiral, of which S is the centre; if a radius SC be drawn to any point C, and another radius SP be drawn at right angles to it, the intercepted tangent CP is known to be equal to the whole length of the interior revolutions of the ſpiral, though infinite in number. If the thread CP be now unlapped from the arch C $r\,q$, it is plain that the firſt motion of the point P is in a direction PT, which is perpendicular to PC, and therefore cuts the radius PS in an angle SPT, equal to the angle SCP; and, ſince this is the caſe in every poſition of the point, it is manifeſt that its path muſt be a ſpiral PQR, cutting the radii in the ſame angle as the ſpiral C $r\,q\,p$. James Bernoulli firſt diſcovered this remarkable property. He alſo remarked, that if a line PH be drawn from every point of the ſpiral, making an angle with the tangent equal to that made by the radius (like an angle of reflection correſponding with the incident ray SP), thoſe reflected rays would all be tangents to another ſimilar and equal ſpiral I v H; ſo that PH = PS. S and H are conjugate foci of an infinitely ſlender pencil; and therefore the ſpiral I v H is the cauſtic by reflection of RQP for rays flowing from S. If another equal and ſimilar ſpiral $x\,v\,y$ roll on I v H, its centre z will deſcribe the ſame ſpiral in another poſition $w\,u\,z$. All theſe things flow from the principles of evolution alone: and Mr Bernoulli traces, with great ingenuity, the connection and dependence of cauſtics, both by reflection and refraction, of cycloidal, and all curves of provolution, and their origin in evolution or involution. A variety of ſuch repetitions of this curve (and many other ſingular properties), made him call it the SPIRA MIRABILIS. He deſired that it ſhould be engraved on his tombſtone, with the inſcription EADEM MUTATA RESURGO, as expreſſive of the reſurrection of the dead. See his two excellent diſſertations in *Act.* Erudit. 1692, March and May.

Another remarkable property of this ſpiral is, that if, inſtead of the thread evolving from the ſpiral, the ſpiral evolve from the ſtraight line PC, the centre S will deſcribe the ſtraight line PS. Of this we have an example in the apparatus exhibited in courſes of experimental philoſophy, in which a double cone deſcends, by rolling along two rulers inclined in an angle to each other (ſee *Graveſande's* Nat. Phil. I. § 210). It is pretty remarkable, that a rolling motion, ſeemingly round C, as a momentary centre, ſhould produce a motion in the ſtraight line SP; and it ſhews the inconcluſiveneſs of the reaſoning, by which many compilers of elements of geometry profeſs to demonſtrate, that the motion of the deſcribing point S is perpendicular to the momentary radius. For here, although this ſeeming momentary radius may be ſhorter than any line that can be named, the real radius of curvature is longer than any line that can be named.

But it is not merely an object of ſpeculative geometric curioſity to mark the intimate relation between the geneſis of curves by evolution and provolution; it may be applied to important purpoſes both in ſcience and in art. Mr McLaurin has given a very inviting example of this in his account of the Newtonian philoſophy; where he exhibits the moon's path in abſolute ſpace, and from this propoſes to inveſtigate the deflecting forces, and *vice verſa*. We have examples of it in the arts, in the formation of the pallets of pendulums, the teeth of wheels, and a remarkable one in Meſſrs Watt and Boulton's ingenious contrivance for producing the rectilineal motion of a piſton rod by the combination of circular motions. M. de la Hire, of the Academy of Sciences at Paris, has been at great pains to ſhew how all motions of evolution may be converted into motions of provolution, in a memoir in 1706. But he would have done a real ſervice, if, inſtead of this ingenious whim, he had ſhewn how all motions of provolution may be traced up to the evolution which is equivalent to them. For there is no organic geneſis of a curvilineal motion ſo ſimple as the evolution of a thread from a curve. It is the primitive geneſis of a circle; and it is in evolution alone that any curvilineal motion is comparable with circular motion. A given curve line is an individual, and therefore its primitive organical geneſis muſt alſo be individual. This is ſtrictly true of evolution. A parabola has but one evolute. But there are infinite motions of provolution which will deſcribe a parabola, or any curve line whatever; therefore theſe are not primitive organical modes of deſcription. That this, however, is the caſe, may be very eaſily ſhewn. Thus let ABCD (fig. 7.) be a parabola, or any curve; and let *a b c d* be any other curve whatever. A figure E *m l k b i* may be found ſuch, that while it rolls along the curve *a b c d*, a point in it ſhall deſcribe the parabola. The proceſs is as follows: Let B *b*, C *c*, D *d*, &c. be a number of perpendiculars to the parabola, cutting the curve *a b c d* in ſo many points. The perpendiculars may be ſo diſpoſed that the points *a*, *b*, *c*, &c. ſhall be equidiſtant. Now we can conſtruct a triangle E *e b* ſo, that the three ſides E *e*, *eb*, and *b*E, ſhall be reſpectively equal to the three lines E *e*, *ef*, F *f*. In like manner may the whole figure be conſtructed, having the little baſes of the triangles reſpectively equal to the ſucceſſive portions of the baſe A *b c d*, and the radii equal to the perpendiculars B *b*, C *c*, D *d*, &c. Let this figure roll on this baſe *c*. While the little ſide *e k* moves from its preſent poſition, and applies itſelf to *e f*, the point E deſcribes an arch E *i* of a circle round the centre *e*, and, falling within the parabola, is ſomewhere between E and F. Then continuing the provolution, while the next ſide *b i* turns round *f* till *i* applies to *g*, the point E deſcribes another arch *i* F *o* round *f*, firſt riſing up and reaching the parabola in F, when the line *b*E coincides with *f*F, and then falling within the parabola till the point *b* begin to riſe again from *f* by the turning of the rolling figure round the point *g*. Reverſing the motion, the ſides *i b*, *b e*, *e k*, &c. apply themſelves in ſucceſſion to the portions *g f*, *f e*, *e d*, &c. of the baſe, and the point E deſcribes an undulating line, conſiſting of arches of circles round the ſucceſſive centres *g*, *f*, *e*, &c. Theſe circular arches all touch the parabola in the points G, F, E, &c. and ſeparate from it a little internally. By diminiſhing the portions of the baſe, and increaſing the number of the triangular elements of the rolling figure without end, it is evident that the figure becomes ultimately curvilineal inſtead of polygonal, and the point E continues in the parabola, and accurately deſcribes it. It is now a curvilineal figure, having its elementary arches equal to the portions of the baſe to which they apply in ſucceſſion, and the radii converging to E equal to the perpendiculars intercepted between the curve ABCD and the baſe. It may therefore be accurately conſtructed.

It is clear, that practical mechanics may derive great advantage from a careful ſtudy of this ſubject. We now ſee motions executed by machinery which imitate almoſt every animal motion. But theſe have been the reſult of many random trials of *wipers*, *ſnail-pieces*, &c. of various kinds, repeatedly corrected, till the deſired motion is at laſt accompliſhed. But it is, as we ſee, a ſcientific problem, to conſtruct a figure which ſhall certainly produce the propoſed motion; nor is the proceſs by any means difficult. But how ſimple, in compariſon, is the production of this motion by evolution. We have only to find the curve line which is touched by all the perpendiculars B *b*, C *c*, D *d*, &c. This naturally leads us to the ſecond problem in this doctrine, namely, to determine the evolute by our knowledge of the involute: a problem of greater difficulty and of greater importance, as it implies, and indeed teaches, the curvature of lines, its meaſure, and the law of its variation in all particular caſes. The evolute of a curve is the geometrical expreſſion, and exhibition to the eye, of both theſe affections of curve lines.

Since the evolved thread is always at right angles to the evolutrix and its tangent, and is itſelf always a tangent of the evolute, it follows, that all lines drawn perpendicular to the arch of any curve, touch the curve line which will generate the given curve by evolution. Were this evolved curve previouſly known to us, we could tell the preciſe point where every perpendicular would touch it; but this being unknown, we muſt determine the points of contact by ſome other method, and by this determination we aſcertain ſo many points of the evolute. The method purſued is this: When two perpendiculars to the propoſed curve are not parallel (which we know from the known poſition of the tangents of our curve), they muſt interſect each other ſomewhere on that ſide of the tangents where they contain an angle leſs than 180°. But when they thus interſect, one of them has already touched the evolute, and the other has not yet reached it. Thus let *b s*, *e s* (fig. 1.) be the two perpendiculars: being tangents to the evolute, the point *s* of their interſection muſt be on its convex ſide, and the unknown points of contact B and E muſt be on different ſides of *s*. Theſe are elementary truths.

Let *e* E approach toward *b* B, and now cut it in *x*. The contact has ſhifted from E to D, and *x* is ſtill between the contacts. When the ſhifting perpendicular comes to the poſition *c* C, the interſection is at *i*, between the contacts B and C. And thus we ſee, that as the perpendiculars to the involute gradually approach, their contacts with the evolute alſo approach, and their interſection is always between them. Hence it legitimately follows, that the ultimate poſition of the interſection (which alone is ſuſceptible of determination by the properties of the involute) is the poſition of the point of contact, and therefore determines a point of the evolute. The problem is therefore reduced to the inveſtigation of this ultimate interſection of two perpendiculars to the propoſed curve, when they coaleſce after gradually approaching. This will be beſt illuſtrated by an example: Therefore let ABC (fig. 8.) be a parabola, of which A is the vertex, AH the axis, and AV one-half of the parameter; let BE and CK be two perpendiculars to the curve, cutting the axis in E and K, and interſecting each other in *r*; draw the ordinates BD, CV, and the tangent BT, and draw BF parallel to the axis, cutting CK in F, and CN in O.

Becauſe the perpendiculars interſect in *r*, we have $rE : EB = EK : BF$. If therefore we can diſcover the ratio of EK to BF, we determine the interſection *r*. But the ratio of EK to BF is compounded of the ratio of EK to BO, and the ratio of BO to BF. The firſt of theſe is the ratio of equality; for DE and VK are, each of them, equal to AV, or half the parameter. Take away the common part VE, and the remainders EK and DV are equal, and DV is equal to BO; therefore $EK : BF = BO : BF$; therefore $rE : rB = BO : BF$, and (by diviſion) $BE : Er = FO : OB$. Now let the point C continually approach to B, and at laſt unite with it. The interſection *r* will unite with a point of contact N on the evolute. The ultimate ratio of FO to OB, or of *f o* : *o* B, is evidently that of ED to DT, or ED to 2DA; therefore BE : EN = ED : 2DA, or as half the parameter to twice the abſciſſa. Thus have we determined a point of the evolute; and we may, in like manner, determine as many as we pleaſe.

But we wiſh to give a general character of this evolute, by referring it to an axis by perpendicular ordinates. It is plain that V is one point of it, becauſe the point E is always diſtant from its ordinate DB by a line equal to AV; and therefore, when B is in A, E will be in V, and *r* will coincide with it. Now draw VP and NQ perpendicular to AH, and NM perpendicular to VP; let EB cut PV in *t*: then, becauſe AV and DE are equal, AD is equal to VE, and VE is equal to one half of DT. Moreover, becauſe BD and NQ are parallel, DE : EQ = BE : EN = DE : DT; therefore DT = EQ, and VE = $\frac{1}{2}$EQ, and therefore = $\frac{1}{3}$VQ; therefore V*t* is $\frac{1}{3}$ of M*t*, and $\frac{1}{2}$MV. This is a characteriſtic property of the evolute. The ſubtangent is $\frac{1}{2}$ of the abſciſſa; in like manner, as in the common parabola, it is double of the abſciſſa. We know therefore that the evolute is a paraboloid, whoſe equation is $ax^2 = y^3$; that is, the cube of any ordinate MN is equal to the parallelopiped whoſe baſe is the ſquare of the abſciſſa VM, and altitude a certain line VP, called the parameter. To find VP, let CR be the perpendicular to the parabola in the point where it is cut by the ordinate at V; draw the ordinate RS of the paraboloid, and RG perpendicular to AH. Then it is evident, from what has been already demonſtrated, that VK is $\frac{1}{2}$ of KG, and $\frac{1}{3}$ of VG; therefore $KG^2 = 4VK^2$, and (in the parabola) $VC^2 = 2VK^2$. Alſo, becauſe KV : VC = KG : GR, we have $GR^2 = 2KG^2 = 8VK^2$; therefore $VP \times RG^2 = 8VP \times VK^2$. But $VG^3 = 27VK^3, = 27VK \times VK^2$; therefore, becauſe in the paraboloid $VP \times VS^2, = SR^3$, or $VP \times RG^2 = VG^3$, we have $8VP \times VK^2 = 27VK \times VK^2$, and $8VP = 27VK$; or VK : VP; that is, AV : VP = 8 : 27; or VP = $\frac{27}{8}$ AV, or $\frac{27}{16}$ of the parameter of the parabola ABC. The evolute of the conical parabola is the curve called the ſemicubical parabola, and its parameter is $\frac{27}{16}$ of the conical parabola.

This inveſtigation is nearly the ſame with that given by Huyghens, which we prefer at preſent to the method generally employed, becauſe it keeps the principle of inference more cloſely in view.

Mr Huyghens has deduced a beautiful corollary from it. Since the parabola ABC is deſcribed by the evolution of the paraboloid VNR, the line RC is equal to the whole evolved arch RNV, together with the redundant tangent line AV. If therefore we take from CR a part C*κ* equal to the redundant AV, the remainder *κ*R is equal to the arch RNV of the paraboloid. We may do this for every poſition of the evolved radius, and thus obtain a ſeries of points V, *β*, *κ*, *δ*, *ε*, of the evolutrix of the paraboloid. We have even an eaſier method for obtaining the length of any part of the arch of the paraboloid, without the previous deſcription of the parabola ABC. Suppoſe P*y* the arch of the paraboloid, and *yz* the tangent; make P*z* = $\frac{8}{27}$ of the parameter, and deſcribe the arch P*u u* of a circle; then draw from every tangent *y z* a parallel line *x v*, cutting the circle in *u*. The length of the arch *y* P is equal to *y z* + *u v*. The celebrated author congratulates himſelf, with great juſtice, on this neat exhibition of a right line equal to the arch of a curve, without the employment of any line higher than the circle. It is the ſecond curve that has been ſo rectified, the cycloid alone having been rectified by plain geometry a very few years before by Sir Chriſtopher Wren. It is very true, and he candidly admits it, that this very curve had been rectified before by Mr William Neill, a young gentleman of Oxford, and favourite pupil of Dr Wallis; as alſo by Mr Van Heuraet, a Dutch gentleman of rank, and an eminent mathematician. But both of theſe gentlemen had done it by means of the quadrature of a curve, conſtructed from the paraboloid after the manner of Dr Barrow, *Lect. Geom.* XI. Nor was this a ſolitary diſcovery in the hands of Mr Huyghens, as the rectification of the cycloid had been in thoſe of Sir Chriſtopher Wren; for the method of inveſtigation furniſhed Mr Huyghens with a general rule, by which he could evolve every ſpecies of paraboloid and hyperboloid, two claſſes of curves which come in the way in almoſt every diſcuſſion in the higher geometry. He obſerves, that the ratio of B*f* to E*e*, being always compounded of the ratios of B*f* to B*o*, and of B*o*, or D*d*, to E*e*; and the ultimate ratio of B*f* to B*o* being that of TE to TD, which is given by the nature of the paraboloid, we can always find the ratio of BE to BN, if we know that of D*d* to E*e*. In all curves, the ratio of D*d* to E*e* (taken indefinitely near), is that of the ſubtangent to the ſum of the ſubtangent and ordinate of a curve conſtructed on the ſame abſciſſa, having its ordinates equal to the ſubnormals DE, *de*, VK, &c. In the conic ſections the ratio is conſtant, becauſe the line ſo conſtructed is a ſtraight line; and, in the parabola, it is parallel to the axis. See farther properties of it in Barrow's *Lect. Geom.* XI.

From this inveſtigation, Mr Huyghens has deduced the following beautiful theorem:

Let *a* be the parameter of the paraboloid, *x* its abſciſſa, and *y* its ordinate; and let the equation be $a^m x^n = y^{m+n}$; let the radius of the evolute meet the tangent through the vertex A in Z. We ſhall always have $BN = \frac{n}{m} BE + \frac{m+n}{m} BZ$. Thus,

$$\text{If } \left.\begin{array}{l} a x = y^2 \\ a^2 x = y^3 \\ a x^2 = y^3 \\ a x^3 = y^4 \\ a^3 x = y^4 \\ \quad\&c. \end{array}\right\} \text{ then } BN = \left\{\begin{array}{l} BE + 2BZ \\ \frac{1}{2}BE + \frac{3}{2}BZ \\ 2BE + 3BZ \\ 3BE + 4BZ \\ \frac{1}{3}BE + \frac{4}{3}BZ. \\ \quad\&c. \end{array}\right.$$

This is an extremely ſimple and perſpicuous method of determining the radius of the evolute, or radius of curvature; and it, at the ſame time, gives us the rectification of many curves. It is plain that every geometrical curve may be thus examined, becauſe the ſubnormals DE, VK are determined; and therefore their differences are determined. Theſe differences are the ſame with the differences of D*d* and E*e*; and therefore the ratio of D*d* to E*e* is determined; that is, the ſubſidiary curve now mentioned can always be conſtructed.

There is a ſingular reſult from this rule, which would hardly have been noticed, if the common method for determining BN had alone been employed. The equation of the paraboloid is ſo ſimple, that the increaſe of the ordinates and diminution of curvature ſeem to keep pace together; yet we have ſeen that, in the vertex of the cubical parabola, the curvature is leſs than any circular curvature that can be named. In the legs, the curvature certainly diminiſhes as they extend farther;

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Such is the theory of evolution and involution as delivered by Mr Huyghens about the year 1672. It was cultivated by the geometers with ſucceſs. Newton prized it highly, and gave a beautiful ſpecimen of its application to the deſcription, rectification, and quadrature of epicycloids, trochoids, and epicycles of all kinds. But it was eclipſed by the fluxionary geometry of Newton, which included this whole theory in one propoſition, virtually the ſame with Mr Huyghens's, but more comprehenſive in its expreſſion, and much more ſimple in its application. Adopting the unqueſtionable principle of Mr Huyghens, that the evolved thread is the radius of a circle which has the ſame flexures with the curve, the point of the evolute will be obtained by finding the length of the radius of the equicurve circle. The formula for this purpoſe is given in the article FLUXIONS of the *Encyclopedia Britannica;* but is incorrectly ſtated $= \frac{\overline{a+4|}^{\frac{3}{2}}}{2\sqrt{a}}$, inſtead of $\frac{\overline{a+4x|}^{\frac{1}{2}}}{2\sqrt{a}}$. The theorem alſo from which it is deduced $\left(r = \frac{\dot{z}^2}{-\dot{x}\ddot{y}}\right)$ is incorrectly printed, and is given without any demonſtration, thereby becoming of very little ſervice to the reader. For which reaſon, it is neceſſary to ſupply the defect in this place.

Therefore let A*bcd*E*f* (fig. 10.) be a circle, of which C is the centre, and ACE a diameter; let the points *b*, *c*, *d*, of the circumference be referred to this diameter by the equidiſtant perpendicular ordinates *bi*, *cg*, *dk*; draw the chords *bc*, *cd*, producing *dc* till it meet the ordinate *bi* in *a*, produce *cg* to the circle in *f*, and join *bf*, *df*; draw *bb*, *cm*, perpendicular to the ordinates; then *bb*, *cm*, *bc*, *md*, *bc*, *cd*, are ultimately proportional to the firſt fluxions of the abſciſſa AE, the ordinate *cg*, and the arch A*c*; alſo *ab*, the difference between *dm* and *cb* is ultimately as the ſecond fluxion of the ordinate. The triangle *abc* is ſimilar to *bdf*; for the angle *abc* is equal to the alternate angle *bcf*, which is equal to *bdf*, ſtanding on the ſame ſegment. The angle *acb* is equal to *bfd*, ſtanding on the ſegment *bcd*; therefore the remaining angles *bac* and *dbf* are equal; therefore $ab : bc = bd : df = \frac{1}{2}bd : \frac{1}{2}df$. Now let the ordinates *bi* and *dk* continually approach the ordinate *cg*, and at laſt unite with it; we ſhall then have *bc* ultimately equal to $\frac{1}{2}bd$, and *cg* ultimately equal to $\frac{1}{2}df$. Therefore, ultimately, $ab : bc = bc : cg$, and $cg = \frac{bc^2}{ab}$.

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When a curve and a circle have the ſame curvature, it is not enough that the firſt fluxions of their abſciſſæ, ordinates, and arches, are the ſame. This would only indicate the poſition of their common tangent. They muſt have the ſame deflection from that tangent. This is always equal to half of the ſecond fluxion of the ordinate. Therefore the circle and curve muſt have the ſame ſecond fluxion of their ordinates. Therefore let D*bcd*F be any curve coinciding with, or oſculated by, the circle A*bcd*. Let its axis be DG, parallel to the diameter AE; and let *cn* be its ordinate. Let D*n* be $= x$, $cn = y$, and $bc = z$. We have $\dot{x}$, $\dot{y}$, $\dot{z}$, reſpectively equal to $\dot{u}$, $\dot{v}$, $\dot{w}$. Therefore the radius of the oſculating circle is $r = \frac{\dot{z}^3}{-\dot{x}\ddot{y}}$ or $r = \frac{\overline{\dot{x}^2 + \dot{y}^2}|^{\frac{3}{2}}}{-\dot{x}\ddot{y}}$, for all curves whatever. (We recommend the careful peruſal of the celebrated 2d corollary of the 10th propoſition of the 2d book of Newton's Principia, where the firſt principles of this doctrine are laid down with great acuteneſs.)

Inſtead of ſuppoſing the ordinates equidiſtant, and conſequently $\dot{x}$ invariable, we might have ſuppoſed the ordinates to increaſe by equal ſteps. In this caſe y would have had no ſecond fluxion. The radius would then be $= \frac{\dot{z}^3}{\dot{y}\ddot{x}}$. Or, laſtly, we might ſuppoſe (and this is very uſual) the arch z to increaſe uniformly. In this caſe $r = \frac{\dot{z}\dot{y}}{\ddot{x}}$: For becauſe $\dot{x}^2 + \dot{y}^2 = \dot{z}^2$, by taking the fluxion of it, $2\dot{x}\ddot{x} + 2\dot{y}\ddot{y} = 0$, and $\ddot{y} = \frac{\dot{x}\ddot{x}}{\dot{y}}$; and therefore $r = \frac{\dot{z}^3}{\dot{y}\ddot{x} - \dot{x}\ddot{y}}, = \frac{\dot{z}^3}{\dot{y}\ddot{x} + \frac{\dot{x}^2\ddot{x}}{\dot{y}}}, = \frac{\dot{y}\dot{z}^3}{\overline{\dot{y}^2 + \dot{x}^2} \times \ddot{x}}, = \frac{\dot{y}\dot{z}}{\ddot{x}}$.

Having thus obtained the radius of curvature, and conſequently a point of the evolute, we determine its form

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form by reference to an abſciſs, without much farther trouble: It only requires the drawing Cp perpendicular to the axis of the propoſed curve, and giving the values of Cp and Dp. If we ſuppoſe $\dot{x}$ conſtant, then, cC being $= \frac{\dot{z}^3}{-\dot{x}\ddot{y}}$, we have D$p$ $(= \mathrm{D}n + gc, = \mathrm{D}n + \frac{\dot{y}}{\dot{z}} \times c\mathrm{C}) = x + \frac{\dot{y}\dot{z}^2}{-\dot{x}\ddot{y}}$; and pC $(= cg - cn, = \frac{\dot{x}}{\dot{z}} \times c\mathrm{C} - cn) = \frac{\dot{z}^2}{-\ddot{y}} - y$. But if we ſuppoſe $\dot{y}$ conſtant; then, cC being $= \frac{\dot{z}^3}{\dot{y}\ddot{x}}$, we have D$p = x + \frac{\dot{z}^2}{\ddot{x}}$, and pC $= \frac{\dot{x}\dot{z}^2}{\dot{y}\ddot{x}} - y$. And if $\dot{z}$ be conſtant, then, cC being $= \frac{\dot{y}\dot{z}}{\ddot{x}}$, we ſhall have D$p$ $= x + \frac{\dot{y}^2}{\ddot{x}}$, and pC $= \frac{\dot{x}\dot{y}}{\ddot{x}} - y$.

Theſe formulæ are ſo many general expreſſions for determining both the curvature of the propoſed curve and the form of its evolute. They alſo give us the rectification of the evolute; becauſe cC is equal to the evolved arch, or to that arch, together with a conſtant part, which was a tangent to the evolute at its vertex, in thoſe caſes where the involute has a finite curvature at its vertex; as in the common parabola.

Let us take the example of the common parabola, that we may compare the two methods. The equation of this is $ax = y^2$, or $a^{\frac{1}{2}} x^{\frac{1}{2}} = y$. This gives $\dot{y} = \frac{1}{2} a^{\frac{1}{2}} \dot{x} x^{-\frac{1}{2}}, = \frac{a^{\frac{1}{2}} \dot{x}}{2x^{\frac{1}{2}}}$, and (making $\dot{x}$ conſtant) $\ddot{y} = -\frac{1}{2} \times \frac{1}{2} a^{\frac{1}{2}} \dot{x}^2 x^{-\frac{3}{2}} = \frac{-a^{\frac{1}{2}} \dot{x}^2}{4x^{\frac{3}{2}}}$. Wherefore $\dot{z}\ (= \sqrt{\dot{x}^2 + \dot{y}^2}) = \frac{\dot{x}}{2}\sqrt{\frac{4x+a}{x}}$, and the radius of curvature $\left(= \frac{\dot{z}^3}{-\dot{x}\ddot{y}}\right) = \frac{\overline{a+4x}|^{\frac{3}{2}}}{2\sqrt{a}}$. At the vertex, where $x = 0$, the formula becomes $= \frac{1}{2}a$. Again, Dp $\left(= x + \frac{\dot{y}\dot{z}^2}{-\dot{x}\ddot{y}}\right)$ becomes $\frac{1}{2}a + 3x$; and therefore V$p = 3x$, = the abſciſſa of our evolute. Likewiſe cp, its ordinate, $\left(= \frac{\dot{z}^2}{-\ddot{y}} - y\right) = \frac{4x^{\frac{3}{2}}}{\sqrt{a}}$; and C$p^2 = \frac{16x^3}{a}$; and C$p^2 \times a = 16x^3$. But V$p = 3x$, and V$p^3 = 27x^3$. Therefore C$p^2 \times \frac{1}{16}$th $a = x^3, = \frac{1}{27}$th Vp^3, and $\frac{27}{16}$ths $a \times$ C$p^2 =$ Vp^3. Therefore the evolute VC is a ſemicubical parabola, whoſe parameter is $\frac{27}{16}a$, as was ſhewn by Mr Huyghens. The arch VC is $= \frac{\overline{a+4x}|^{\frac{3}{2}}}{2\sqrt{a}} - \frac{1}{2}a$.

We ſhall give one other example, which comprehends the whole claſs of paraboloids. Their general equation is $y = ax^n$. This gives us $\dot{y} = nax^{n-1}\dot{x}$, and $\ddot{y} = n \times \overline{n-1} \times ax^{n-2}\dot{x}^2$; therefore $\dot{z}\ (= \sqrt{\dot{x}^2 + \dot{y}^2}) = \dot{x}\sqrt{1 + n^2a^2x^{2n-2}}$; C$c$ $\left(= \frac{\dot{z}^3}{-\dot{x}\ddot{y}}\right) = \frac{\overline{1 + n^2a^2x^{2n-2}}|^{\frac{3}{2}}}{-n \times \overline{n-1} \times ax^{n-2}}$; D$p$ $\left(= x + \frac{\dot{y}\dot{z}^2}{-\dot{y}\dot{x}}\right) = x - \frac{x + n^2a^2x^{2n-1}}{n-1}$; C$p$ $\left(= \frac{\dot{z}^2}{\ddot{y}} - y\right) = \frac{1 + \overline{2n-1} \times na^2x^{2n-2}}{-\overline{n-1} \times nax^{n-2}}$; and DV $= -\frac{n^2a^2o^{2n-1}}{n-1}$

This laſt formula expreſſes the radius of curvature at the vextex D, or the redundant part of the thread, by which it exceeds the arch VC of the evolute. If $n = \frac{1}{2}$, the formula becomes $\frac{a^2}{2}$: but if n be greater than this, VC will be $= o$; and if it be leſs, VC will be infinite. Hence it appears, that the radius of curvature at the vertex of a curve is a finite quantity only in the caſes where the firſt or naſcent ordinates are in the ſubduplicate ratio of their abſciſſæ. In all other caſes, the curvature is incomparable with that of any circle, being either what is called infinite (when n is greater than $\frac{1}{2}$) or nothing (when it is leſs).

We ſcruple not to ſay, that the method of Mr Huyghens is more luminous, more pleaſing to the imagination of a geometer, than this; and in all the caſes which occurred to us in our employment of it, it ſuggeſted more ready conſtructions, with the additional ſatiſfaction of exhibiting, in a continuous train, what the *ſymbolical* method, proceeding by the fluxionary calculus, only indicates by points. We muſt alſo obſerve, that the ſubſidiary curve employed by Huyghens, having its ordinates equal to the ſubnormals of the involute under examination, is the geometrical expreſſion of that function of the involute which gives the ſecond fluxions $\ddot{y}$ and $\ddot{x}$ of the ordinate and abſciſſa. The young mathematician will find no difficulty in conſtructing this curve *in every caſe;* whereas we imagine that he will not find it a light matter to conſtruct the final equations of the ſymbolic method *almoſt in any caſe.* At the ſame time, the all comprehending extent of the latter method, and the numberleſs general theorems which it ſuggeſts to the expert analyſt, give it a moſt deſerved preference, and make it almoſt an indiſpenſable inſtrument for all who would extend our phyſico-mathematical ſciences.

In the employment of the geometry of curve lines, eſpecially in the doctrine of centripetal forces, it is uſual to conſider the ordinates, not as inſiſting on a rectilineal abſciſſa, but as diverging from a centre. This is alſo the uſual way of conceiving all ſpirals and evolutrixes of curves which include ſpace; in ſhort, all RADIAL curves. The proceſs for finding their evolute, or their radius of curvature, is ſomewhat different from that hitherto exhibited; but it is more ſimple. Thus, let GPM (fig. 10.) be the elliptical path of a planet, of which S is the focus. We require PC, the radius of curvature in the point P. Let Pp be a very ſmall arch. Draw the radii SP, Sp, the tangents PT, pt;

and draw ST perpendicular to PT, cutting pt in t; and Po perpendicular to Sp. Let the arch GP be $= z$, the radius SP $= y$, and the perpendicular ST $= p$. Then, it is plain, that Pp, op, Tt, are ultimately proportional to $\dot{z}, \dot{y}, \dot{p}$. The triangles PC$p$, and T$pt$ or TPt are alſo ultimately ſimilar; as alſo the triangles PST and poP. Therefore, ultimately,

$$\mathrm{T}t : \mathrm{P}p = \mathrm{PT} : \mathrm{PC}$$

alſo $$\mathrm{P}p : po = \mathrm{PS} : \mathrm{PT}$$

therefore $\mathrm{T}t : po = \mathrm{PS} : \mathrm{PC}$, or, $\dot{p} : \dot{y} = y : r$, and $r = \frac{y\dot{y}}{\dot{p}}$; an expreſſion of the radius of curvature, extremely ſimple, and of eaſy application.

The logarithmic or equiangular ſpiral PQR (fig. 6.) affords an eaſy example of the uſe of this formula. The angle SPT, which the ordinate makes with the curve, is everywhere the ſame. Therefore let a be our tabular radius, and b the ſine of the angle SPT. We have $\mathrm{ST} = \frac{by}{a}$; and therefore $\mathrm{PC}\left(= \frac{y\dot{y}}{\dot{p}}\right) = \frac{ay\dot{y}}{b\dot{y}} = \frac{ay}{b}$. This is to SP or y in the conſtant ratio of a to b, or of SP to ST: that is, ST : SP = SP : PC, the triangles SPT and PCS are ſimilar, the angles at P and C equal, and C is a point of an equiangular ſpiral pyr round the centre S.

It is not meant that the conſtruction pointed out by this theory of involution, expreſſed in its moſt general and ſimple form, is always the beſt for finding the centre of the equicurve circle. Our knowledge of, or attention to, many other properties of the curve under conſideration, beſides thoſe which ſimply mark its relation to an abſciſs and ordinate, muſt frequently give us better conſtructions. But evolution is the natural geneſis of a line of varying curvature. Moreover, in the moſt important employment of mathematical knowledge, namely, mechanical philoſophy, it is well known, that the moſt certain and comprehenſive method of ſolving all intricate problems is by reference of all forces and motions to three co-ordinates perpendicular to each other. Thus, without any intentional ſearch, we have already in our hands the very fluxionary quantities employed in this doctrine; and the expreſſion which it gives of the radius of curvature requires only a change of terms to make it a mechanical theorem.

Thus have we conſidered the two chief queſtions of evolution and involution. We have done it with as cloſe attention to geometry as poſſible, that the reader's mind may become familiar with the *ipſa corpora* while acquiring the elementary knowledge, which is to be employed more expeditiouſly afterwards by the help of the ſymbolical analyſis. Without ſuch ideas in the mind, the occupation is oftentimes as much diveſted of thought as that of an expert accountant engaged in complex calculations; the attention is wholly turned to the rules of his art.

It now remains to conſider a little the nature of this curvature of which ſo much has been ſaid, and about which ſo many obſcure opinions have been entertained. We mentioned, in an early part of this article, the unwarranted uſe of the terms of infinite and infiniteſimal magnitude as applicable to curvature, and ſhewed its impropriety by the inconſiſtences into which it leads mathematicians. Nothing threw ſo much light on this ſubject as Mr Huyghens's Geometry of Evolution; and we ſhould have expected that all diſputes would have been ended by it. But this has not been the caſe; and even the moſt eminent geometers and metaphyſicians, ſuch as the Bernoullis and Leibnitz, have given explanations of orders of curvature that can have no exiſtence, and explanations of that coaleſcence which obtains between a curve line and its equicurve circle, which are not warranted by juſt principles.

Theſe errors (for ſuch we preſume to think them) aroſe from the method employed by the geometers of laſt century for obtaining a knowledge of the magnitude and variation of curvature. The ſcrupulous geometers of antiquity deſpaired of ever being able to compare a curve with a right line. The moderns, although taught by Des Cartes to define the nature of a curve by its equation, allowed that this only enabled them to exhibit a ſeries of points through which it paſſed, and to draw the polygon which connects theſe points, but gave no information concerning the continuous *incurvated* arches, of which the ſides of the polygon are the chords. They could not generally draw a tangent to any point, or from any point; but they could draw a chord through any two points. Des Cartes was the firſt who could draw a tangent. He contrived it ſo, that the equation which expreſſes the interſections of the curve with a circle deſcribed round a given centre ſhould have two equal roots. This indicates the coaleſcence of two interſections of the common chord of the circle and the curve. Therefore a perpendicular to the radius ſo determined muſt touch the curve in the point of their union. This was undoubtedly a great diſcovery, and worthy of his genius. It naturally led the way to a much greater diſcovery. A circle may cut a curve in more points than two: It may cut a conic ſection in four points; all expreſſed by one equation, having four roots or ſolutions. What if three of theſe roots ſhould be equal? This not only indicates a cloſer union than a mere contact, but alſo gives indication of the flexure of the intervening arch. For, before the union, the interſections were in the arch both of the curve and of the circle; and therefore the diſtinction between the union of two and of three interſections muſt be of the ſame kind with that between a ſtraight line and an arch of *this* circle. The flexure of a circle being the ſame in every part, it becomes a proper index; and therefore the circle, which is determined by the coaleſcence of three interſections, was taken as the meaſure of the curvature in that point of the curve, and was called the CIRCLE OF CURVATURE, the EQUICURVE CIRCLE. There is a certain progreſs to this coaleſcence which muſt be noticed. Let ABD (fig. 4.) be a common parabola, EBF a line touching it in B, and BO a line perpendicular to EBF. Taking ſome point O in the other ſide of the axis for a centre, a circle may be deſcribed which cuts the curve in four points a, b, c, and d. By enlarging the radius, it is plain that the points a and b muſt ſeparate, as alſo the points c and d. Thus, the points b and c approach each other, and at laſt coaleſce in a point of contact B, with the parabola, and with its tangent. In the mean time, a and d have retired to A and D. If we now bring the centre O nearer to B, the new circle will fall wholly within the laſt circle ABD; and therefore both

A and D will again approach to each other, and to B, which ſtill continues a point of contact. It is plain that A will approach faſter to B than D will do. At length, the centre being in o, the point A coaleſces with B, and we obtain a circle ι B δ, touching the curve in B, and cutting it in δ: Conſequently the arch B $\iota\delta$ is wholly within, and B $\varphi\delta$ is wholly without the parabola; and the circle both touches and cuts the parabola in B. Here is certainly a cloſer union, at leaſt on the ſide of a. But perhaps a farther diminution of the circle may bring it cloſer on the ſide of D. Join B δ. Let a ſmaller circle be deſcribed, touching the parabola in B, and cutting it in φ. Draw φc parallel to δ B. It may be demonſtrated that the new circle cuts the parabola in c. Now the arch between c and φ being without the parabola, the arch B C muſt be within it; and therefore this circle is within the parabola on both ſides of B, and is more incurvated than the parabola. We have ſeen, that a circle greater than ι B δ is without the parabola on both ſides of B; and therefore is leſs incurvated than the parabola. Therefore the individual circle ι B δ is neither more nor leſs curve than the parabola in the point B. Therefore the circle indicated by the coaleſcence of three interſections is properly named the equicurve circle; and, ſince we meaſure all curvatures by that of a circle, it is *properly* the circle of curvature, and its radius is the radius of curvature.

Had B been the vertex of the axis, every interſection on one ſide of B would have been ſimilar to an interſection on the other, and there would always have been two pairs of roots that are equal; and therefore when three interſections coaleſce, a fourth alſo coaleſces, and the contact is ſaid to be ſtill cloſer.

What has now been ſhewn with reſpect to a conic ſection is true of every curve. When two interſections coaleſce, there is a common tangent; when three coaleſce, there is an equal curvature, and no other circle can paſs between this circle and the curve. There cannot be a coaleſcence of four interſections, except when the diameter is perpendicular to the ordinates, and thoſe are biſected by the diameter.

Mr Leibnitz, who valued himſelf for metaphyſical refinement, and never fails to claim ſuperiority in this particular, notices the important diſtinction between a ſimple contact and this cloſer union, in a very well written diſſertation, publiſhed in the *Acta Eruditorum*, July 1686. He calls the contact of equal curvatures an OSCULATION, and the circle of equal curvature the OSCULATING CIRCLE, and delivers ſeveral very judicious remarks with the tone of a maſter and inſtructor. He alſo ſpeaks of different degrees or orders of oſculation, each of which is infinitely cloſer than the other, as a thing not remarked by geometers. But Sir Iſaac Newton had done all this before. The firſt twelve propoſitions of the *Principia* had been read to the Royal Society ſeveral years before, and were in the Regiſters. The *Principia* had received the imprimatur of the Society in July 1686; but was almoſt printed before that time. In the Scholium to the 11th Lemma, is contained the whole doctrine of contact and oſculation; and in the lemma and its corollaries, is crowded a body of doctrine, which has afforded themes for volumes. The author glances with an eagle's eye over the whole proſpect, and points out the prominent parts with the moſt compreſſed brevity; but with ſufficient preciſion for marking out the more important objects, and particularly the different orders of curvature. This lemma and its corollaries are continually employed in the twelve propoſitions already mentioned. In 1671 he had written the firſt draught of his method of fluxions, where this doctrine is ſyſtematically treated; and Mr Collins had a copy of it ever ſince 1676. It is well known that Leibnitz, when in London, had the free peruſal of the Society's records, and information at all times by his correſpondence with the ſecretary Oldenburgh and Mr Collins. His conduct reſpecting the theorems concerning the elliptical motion of the planets, and the reſiſtance of fluids, leave little room to doubt of his having availed himſelf in like manner of his opportunity of information on this ſubject. He gives a much better account of the Newtonian doctrine on this ſubject than in thoſe other inſtances, it being more ſuited to his refining and paradoxical diſpoſition.

In this and another diſſertation, he conſiders more particularly the nature of evolution, and of that oſculation which obtains between the evolutrix and the circle deſcribed by the evolved radius. He ſays, that it is equivalent to two ſimple contacts, each of which is equivalent to two interſections. An oſculation produced in the evolution of a curve is therefore equivalent to four interſections. And he adviſes, with an air of authority, the mathematicians to attend to theſe remarks, as leading them into the receſſes of ſcience. He is miſtaken, however; and the liſtening to him would prevent us from forming a juſt notion of oſculation, and from conceiving with diſtinctneſs the ſingular fact of a circle both touching and cutting a curve in the ſame point. James Bernoulli loſt his friendſhip, becauſe he preſumed to ſay that the preſence of four interſections in an oſculation is not warranted by the equation expreſſing thoſe interſections.

Mr Leibnitz was miſled by the way in which he had conſidered the oſculation in the evolution of curves. It merits attention. From any point within the ſpace ADFOA (fig. 1.), two perpendiculars may be drawn to the evolutrix A bdf; and therefore two circles may be deſcribed round that point, each touching the curve. Each contact is the union of two interſections. Therefore, as the centre approaches the evolute, the contacts approach each other, and they unite when the centre reaches the evolute. Therefore the oſculation of evolution is equivalent to four interſections.

But when two ſuch circles are deſcribed round a point s, ſo as that both may touch the evolutrix A af, the point s is in the interſection of one evolved radius with the *prolongation* of another. The contact at the extremity b of the prolonged radius b B is an exterior contact, and the arch of the circle croſſes the evolutrix, from without inwards, in ſome point more remote from A. The contact at the extremity e of the radius e E is an interior contact; and if es be greater than the ſtraight line EA, the arch of this circle croſſes the curve, from within outwards, in ſome point nearer to A. Thus each contact is accompanied by an interſection on the ſide next the other contact, ſometimes beyond it, and ſometimes between the contacts. As the contacts approach, the interſections alſo approach, ſtill retaining their characters as interſections, as the contacts ſtill continue contacts. Alſo the circle next to A croſſes from without inwards, and that next to f croſſes from within outwards. They retain this character to the laſt; and when the contacts coaleſce, the two circles coaleſce over their whole circumference, ſtill, however, croſſing the curve in the ſame direction as before; that is, without the curve on the ſide of A, and within it on the ſide of *f*. The contacts unite as contacts, and the interſections as interſections. Thus it is that the oſculating circle both touches and interſects the curve in the ſame point.

At *f* the oſculation is indeed cloſer than anywhere elſe. The variation of curvature is leſs there than anywhere elſe, becauſe the radius changes more ſlowly. It is this circumſtance that determines the cloſeneſs of contact. If a circle oſculates a curve, it has the ſame curvature. If this curvature does not change in the vicinity of the contact, the curve and circle muſt coincide; and the deviation of the circle (the curvature of which is everywhere the ſame) from the curve muſt proceed entirely from the variation of its curvature. This, therefore, is the important circumſtance, and is indeed the characteriſtic of the figure as a curve line; and its other properties, by which the poſition of its different parts are determined, may be aſcertained by means of the *variation* of its curvature, as well as by its relation to co-ordinates. Of this we have a remarkable inſtance at this very time. The orbit of the newly diſcovered planet has been aſcertained with tolerable preciſion by means of obſervations made on its motions for three years. In this time it had not deſcribed the 20th part of its orbit; yet the figure of this orbit, the poſition of its tranſverſe axis, the place and time of its perihelion, were all determined within 100dth part of the truth by the *obſerved variation* of its curvature. It therefore merits our attention in the cloſe of this article. We know of no author who has treated the ſubject in ſo inſtructive a manner as Mr M'Laurin has done, by exhibiting the theorem which conſtitutes Newton's 11th lemma in a form which points this out even to the eye (ſee *M'Laurin's Fluxions*, Chap xi. § 363, &c.). We earneſtly recommend this work to the young geometer, as containing a fund of inſtruction and agreeable exerciſe to the mathematical genius, and as greatly ſuperior in perſpicuity and in ideas which can be treaſured up and recollected, when required, to the greateſt part of the elaborate performances of the eminent analyſts of later times. By expreſſing every thing geometrically, the author furniſhes us with a ſort of picture, which the imagination readily reviews, and which exhibits in a train what mere ſymbols only give us a momentary glimpſe of.

" As, of all right lines which can be drawn through a given point in the arch of a curve, that alone is the tangent which touches the arch ſo cloſely that no right line can paſs between them; ſo, of all circles which touch a curve in a given point, that circle alone has the ſame curvature which touches it ſo cloſely that no circle can paſs between them. It cannot coincide with the arch of the curve; and therefore the above condition is ſufficient for making it equicurve. As the curve ſeparates from the tangent by its flexure or curvature, it ſeparates from the equicurve circle by its *change* of curvature; and as its curvature is greater or leſs according as it ſeparates more or leſs from its tangent, ſo the variation of its curvature is greater or leſs according as it ſeparates more or leſs from its equicurve circle. There can be but one equicurve circle at one point of a curve, otherwiſe any other circle deſcribed between them through that point will paſs between the curve and the equicurve circle.

" When two curves touch each other in ſuch a manner that no circle can paſs between them, they muſt have the ſame curvature; becauſe the arch which touches one of them ſo cloſely that no circle can paſs between them, muſt touch the other in like manner. But circles may touch the curve in this manner, and yet there may be indefinite degrees of more or leſs intimate contact between the curve and its equicurve circle." This is ſhewn by the ingenious author in a ſeries of propoſitions, of which a very ſhort abridgment muſt ſuffice in this place.

Let any curve EMH (fig. 11.), and a circle ERB, touch a right line ET on the ſame ſide at E. Let any right line TK, parallel to the chord EB of the circle, meet the tangent in T, the curve in M, and a curve BKF (which paſſes through B) in K. Then, if $MT \times TK$ be everywhere equal to TE^2, the curvature of EMH in the point E is the ſame as that of the circle ERB; and the contact of EM and ER is ſo much the cloſer the ſmaller the angle is which is contained at B between the curve BKF and the equicurve circle BQE.

Let TK meet the circle in R and Q. Then, becauſe $RT \times TQ = TE^2$, it muſt be $RT \times TQ = MT \times TK$; and $RT : MT = TK : TQ$. The line BKF may have any form. It may croſs the circle BQR in B, as in the figure. It may touch it, or touch EB, &c. Let us firſt conſider what ſituations of the point M correſpond with the poſition of K, in that part of the curve BKF which lies without the circle BRE. Let TK move toward EB, always keeping parallel to it, till it coincide with it, or even paſs it. Then, while the point K deſcribes KB, it is evident that ſince TK is greater than TQ, TM muſt be leſs than TR, and the point M muſt always be found between T and R. The arch ME of the curve muſt be nearer to the tangent than the arch RE of the circle. If any circle be now deſcribed touching TE in E, and cutting off from EB a ſmaller chord than EB, it is clear that the whole of this ſegment muſt be within the ſegment BRE; therefore this ſmaller circle does not paſs between ERB and the curve EMH. But ſince we ſee that the curve lies without the circle, in the vicinity of E, perhaps a greater circle than ERB may paſs between it and the curve. A greater circle, touching at E, muſt cut off a chord greater than EB. Let E*rb* be ſuch a circle, cutting EB in *b*, and TQ in *q*. T*q* is neceſſarily greater than TQ. For ſince *b* is beyond B, and the arch BKF lies in the angle QB*b*, the circle E*rq* muſt croſs the curve FKB in ſome point; ſuppoſe F. Then while K is found in the arch FB, the point *q* muſt be beyond K, or T*q* muſt be greater than TK. Now $Tr \times Tq = TE^2, = TM \times TQ$. Therefore $TM : Tr = Tq : TQ$. Therefore T*q* being greater than TQ, T*r* muſt be leſs than TM, and the point *r* muſt lie without the curve, and the arch E*r* does not paſs between EMH and the circle ERB. In like manner, on the other ſide of EB, it will appear, that when the curve BK′F falls within the circle which touches EMH in E, and cuts off the chord EB, the arch of the curve correſponding to the arch BKF′, lying within the circle, alſo lies within the circle. For TK′ being leſs than TQ′, TM′ is greater than TR′, and the curve is within the circle. And, by ſimilar reaſoning, it is evident that a circle cutting off a greater chord falls without both the circle ERB and the curve, and that a circle leſs than ERB muſt neceſſarily leave ſome part of the curve $BK'F$ without it; and therefore TK' will be greater than Tq', and the correſponding point r' muſt be without the curve. All circles therefore touching TE in E fall without both ER and EM, or within them both, according as they cut off from EB a chord greater or leſs than EB, and no circle can paſs between them when the rectangle $MT \times TK$ is always equal to ET^2, and the focus of the point K paſſes through B; that is, ERB is the equicurve circle at E.

This corroborates the ſeveral remarks that we have made on the circumſtance of a circle touching and cutting a curve in the ſame point. No other circle can be made to paſs between it and the curve, and it therefore has the ſame curvature. This may therefore be taken as a ſufficient indication of the equicurve circle; the character peculiarly aſſured to it by the nature of evolution. It muſt be noted, however, that the curve is ſuppoſed to have its concavity in the vicinity of the contact turned all the ſame way. For if the contact be in a point of contrary fluxure, even a ſtraight line will both touch and cut it in that point.

The reader cannot but remark, that MK is always the chord of a circle touching TE in E, and paſſing through M.

Let Em be another curve, touching TE in E, ſuch, that the conjugate curve kB, which always gives $Tm \times Tk = TE^2$, alſo paſſes through B. Then, by what has now been demonſtrated, the two curves EM and Em have the ſame equicurve circle ERB, and conſequently the ſame curvature in E. Then, becauſe the rectangles $RT \times TQ$, $MT \times TK$, and $mT \times Tk$, are equal, we have $Tm : TM = TK : Tk$. Therefore if the arch Bk paſs between BK and BQ, the curve Em muſt paſs between the curve EM and the circle ER. Em muſt therefore have a cloſer contact with ER than EM has with it; and the ſmaller the angle QBK is which is contained between the curve and its equicurve circle, the cloſer is the contact of the curve EM and its equicurve circle ER. Thus the length of the chord EB determines the *magnitude* or degree of curvature at E, when compared with another; and the angle contained between the equicurve circle and the conjugate curve BKF determines the cloſeneſs of the contact of the curve with its equicurve circle (the angle TEB being ſuppoſed the ſame in both).

It appears, from the proceſs of demonſtration, that the curve EMH falls without or within the equicurve circle according as its conjugate curve BKF does. Alſo, when BKF cuts BQR, HME alſo cuts it. But if FQB is on the ſame ſide of QB on both ſides of the interſection B, the curve HME is alſo on the ſame ſide of it on both ſides of the contact E. It is alſo very clear, that the contact or approach to coaleſcence between the curve and its circle of curvature, is ſo much the cloſer as the conjugate curve BKF comes nearer to the adjoining arch of this circle. It muſt be the cloſeſt of all when KB touches QB, and it muſt be the leaſt ſo when KB touches EB, or has EB for an aſſymptote. The ſpace QBK is a ſort of magnified picture of the ſpace MER; and we have a ſenſible proportion of TQ to TK as the repreſentation of the proportion of TM to TR, quantities which are frequently evaneſcent and inſenſible. When QBK is a finite angle, that is, when the tangents of BQ and BK do not coincide, the angle QBK can be meaſured. But no rectilineal angle can be contained as an unit in the curvilineal angle MER. They are incommenſurable, or incomparable. Let the curve KB touch the circle QB without cutting it. This angle is equally incomparable with the former QBK; yet it has a counterpart in MER. This muſt be incomparable with the former in the ſame manner; for there is the ſame proportion between the individuals of both pairs. Thus it appears plainly, that there are curvilineal angles incomparable with each other. Yet are they magnitudes of one kind; becauſe the ſmalleſt rectilineal angle muſt certainly contain them both; and one of them contains the other. But, further, there may be indefinite degrees of this coaleſcence or cloſeneſs of contact between a curve and a circle. The firſt degree is when the ſame right line touches both. This is a *ſimple contact*, and may obtain between any curve and any circle. The next is when EMH and ERB have the ſame curvature, and when the conjugate curve FKB interſects the circle QB in any aſſignable angle. This is an *oſculation*. The third degree of contact, and ſecond of oſculation, is when the curve KB touches the circle QB, but not ſo as to oſculate. The fourth degree of contact, and third of oſculation, is when KB and QB have the ſame curvature or oſculate in the firſt degree of oſculation. This gradation of more and more intimate contact, or (more properly ſpeaking) of approximation to coaleſcence, may be continued without end, "*neque novit natura limitem*," the contact of EM and ER being always two degrees cloſer than that of BK and BQ. Moreover, in each of thoſe claſſes of contact there may be indefinite degrees. Thus, when EM and ER have the ſame curvature, the angle QBK admits of indefinite varieties, each of which aſcertains a different cloſeneſs of contact at E. Alſo, though the angle QBK ſhould be the ſame, the contact at E will be ſo much the cloſer the greater the chord EB is.

For $TR : TM = TK : TQ$

Therefore $RM : TR = KQ : KT$

Or $RM : KQ = TR : TK; = TR \times TQ : TK \times TQ, = TE^2 : TK \times TQ$.

Therefore, when TE is given, RM (which is then the meaſure of the angle of contact) is proportional to KQ directly, and to the rectangle $TK \times TQ$ inverſely; and when KQ is given, RM is leſs in proportion as $KT \times TQ$ is greater. In the very neighbourhood of E and B, it is plain that $KT \times TQ$ is very nearly equal to EB^2, and therefore ultimately $RM : KQ = ET^2 : EB^2$.

It will greatly aſſiſt our conception of this delicate ſubject, if we view the origin of theſe degrees of contact as they are generated by the evolution of lines. A thread evolving from a polygon EDCBA (fig. 13.) deſcribes with its extremity *a* a line *edbca*, conſiſting of ſucceſſive arches of circles united in ſimple contacts. If it evolve from any continuous curve CBA, after having evolved from the lines ED, BC, the arch *cb* will be united with the circular arch *dc* by oſculation of the firſt degree. If any other curve FC touch this evolute in a ſimple contact, and if the two curves FCBA and DCBA are both evolved, they will touch each other in a ſimple oſculation in that point where they have the ſame radius. If FC touches DC in a ſimple oſculation, the evolved curves will touch in an oſculation of the ſecond degree; and, in general, the oſculation of the two generated curves is a degree cloſer than that of their evolutes; and in each ſtate of one of the oſculations, there is an indefinite variety of the other, according to the length of its radius of curvature. All this is very clear; and ſhews, that theſe degrees of contact do not indicate degrees of curvature, one of which infinitely exceeds another; for they are all finite.

The reader will do well to remark, that the magnitude, which is the ſubject of the above proportions, which is really of the ſame kind in them all, and conſidered as ſuſceptible of various degrees and orders of infiniteſimals, is not curvature, but lineal extenſion. It is RM, the ſubtenſe of the angle of contact MER. It is the linear ſeparation from the tangent, or from the equicurve circle. It is, however, uſually conſidered as the meaſure of curvature, or the proportions of this line are given as the proportions of the curvature. This is inaccurate; for curvature is unqueſtionably a change of direction only. As this line has generally been the intereſting object in the refined ſtudy of curve lines, eſpecially in the employment of it in the diſcuſſions of mechanical philoſophy, it has attracted the whole attention, and the language is now appropriated to this conſideration. What is called, by the moſt eminent mathematicians, variation of curvature, is, in fact, variation of the ſubtenſe of the angle of contact. But it is neceſſary always to diſtinguiſh them carefully.

Variation of curvature is the remaining object of our attention.

Curvature is uniform in the circle alone. When the curvature of the arch EMH (fig. 11.) decreaſes as we recede from E, the arch, being leſs deflected from its primitive direction ET than the arch ER, muſt ſeparate leſs from the line ET, or muſt fall without the arch ER. The more rapidly its curvature decreaſes, the deſcribing point muſt be left more without the circle. It muſt be the contrary, if its curvature had increaſed from E toward M. It may change its curve equably or unequably. If equably, there muſt be a certain uniform rate, which would have produced the ſame final change of direction in a line of the ſame length, bending it into the uniformly incurvated arch of a circle. It is not ſo obvious how to eſtimate a rate of variation of curvature; and authors of eminence have differed in this eſtimation. Sir Iſaac Newton, who was much intereſted in this diſcuſſion, in his ſtudies on univerſal gravitation, ſeems to have adopted a meaſure which beſt ſuited his own views; and has been followed by the greater number. He gives a very clear conception of what he means, by ſtating what he thinks a caſe of an invariable rate of variation. This is the equiangular ſpiral, all the arches of which, comprehended in equal angles from the centre, are perfectly ſimilar, although continually varying in curvature. He calls this a curve EQUABLY VARIABLE, and makes its rate of variation (eſtimated in that ſenſe in which it is uniform) the meaſure of the rate of variation in all other curves. Let us ſee in what reſpect its variation of curvature is conſtant. It may be deſcribed by the evolution of the ſame ſpiral in another poſition (ſee fig. 6.), and the ratio between the radius of the evolute and that of the evolutrix is always the ſame; or (which amounts to the ſame thing) the arch of the evolutrix bears to the evolved arch of the evolute a conſtant ratio. The curvature of the ſpiral changes more rapidly in the ſame proportion as the ratio of the evolved arch to the arch of the evolutrix generated by it is greater, or as it cuts the radii in a more acute angle. Theſe arches may be infiniteſimal; therefore the fraction $\frac{\text{fluxion of evolute}}{\text{fluxion of evolutrix}}$ expreſſes the rate of the variation of curvature in this ſpiral. Now let $abcd$ (fig. 13.) be any other curve, and ABCD its evolute; let p be the centre of curvature at the point B of the evolute, and Bo the evolved arch; draw the radii pB, po, Bm, on; join pm, and draw Bq perpendicular to pm. It is evident that mn and Bo have the ſame ratio with Bm and Bp; and that theſe two ſmall arches may be conceived as being portions of the ſame equiangular ſpiral (perhaps in another poſition), of which q is the centre; and that p is in the curve of another of the ſame. For $qp : q\mathrm{B} = q\mathrm{B} : q\mathrm{M}, = p\mathrm{B} : \mathrm{B}m$; therefore the ratio of theſe infiniteſimal arches mn and Bo will expreſs the rate of variation in any curve. This is evidently equivalent to ſaying, that the variation of curvature is proportional to the fluxion of the radius of curvature directly, and the fluxion of the curve inverſely. For mn and Bo are ultimately as thoſe fluxions, and $\frac{\mathrm{B}o}{mn}$ is equivalent to $\frac{-\dot{r}}{\dot{z}}$, where z is the arch of the ſpiral, and r the evolved radius of the other. Accordingly, this is the enunciation of the INDEX OF VARIATION given by Newton (See Newton's Fluxions, Prob. VI. § 3). Therefore, what Newton calls a uniform variation of curvature, is not an increaſe or diminution by equal arithmetical differences, but by equal proportions of the curvature in every point. The variation of curvature in ſimilar points of ſimilar arches is ſuppoſed to be the ſame.

It is evident that this ratio is the ſame with that of radius to the tangent of the angle pmB, or of 1 to its tabular tangent. The tangent therefore of this angle correſponding to any point of a curve is the meaſure of the variation of curvature in that point. Now it may be ſhewn (and it will appear by and bye), that the fluxion of TK in fig. 11. or the ultimate value of KQ, is always ⅔ds of the fluxion of the radius of curvature. Therefore the tangent of the angle QBK is always ⅔ds of that of pmB; and therefore the angle QBK, which we have ſeen to be an index of the cloſeneſs of contact, is alſo the index of the variation of curvature (See *M'Laurin*, § 386.).

Sir Iſaac Newton has given ſpecimens of the uſe of this meaſure in a variety of geometrical curves, by means of a general expreſſion of $\frac{\dot{r}}{\dot{z}}$. Thus, in the curve ABC (fig. 8.), let AB be $= z$, AD $= x$, DB $= y$, BN $= r$, and BE $= p$; we have $\frac{\mathrm{N}n}{\mathrm{B}b} = \frac{\dot{r}}{\dot{z}}$. Now DB : BE $= y : p, = \mathrm{D}d : \mathrm{B}b, = \dot{x} : \dot{z}$. Therefore $\dot{z} = \frac{p\dot{x}}{y}$, and $\frac{\dot{r}}{\dot{z}} = \frac{y\dot{r}}{p\dot{x}}$. Now, in every curve which we can expreſs by an equation, we can obtain all theſe quantities p, y, $\dot{r}$, and $\dot{z}$, and can therefore obtain the meaſure of the variation of curvature. It is alſo deſerves particular notice, that this inveſtigation of $\frac{\dot{r}}{\dot{z}}$ is equivalent with finding the centre and radius of curvature of the evolute, by which the curve under conſideration is generated; or with finding the centre q (fig. 13.) of an equiangular ſpiral, which will touch our curve in m, its evolute in B, and the evolute of the evolute in p, if put into different poſitions when neceſſary. This leads to very curious ſpeculations, for which, however, we have no room It has been ſaid, for inſtance, that the curvature at the interſection of a cycloid with its baſe is infinitely greater than that of any circle. If the evolution of the cycloid begin from this point, the curvature of its evolutrix will be infinitely greater ſtill upon the ſame principles; and we ſhall have one infinitely greater than this by evolving it. Yet all theſe infinites, multiplied to infinity, are contained in the central point of every equiangular ſpiral! In like manner, there are evolutrixes which coincide with a ſtraight line, and others of infinitely greater rectitude, and ſtill they are curves. Can this have any meaning? And can it be reconciled with the legitimate reaſoning from the ſame principles, that all theſe curvatures and angles of contact are producible by evolution; and that they may be, and certainly are every day deſcribed, by bodies moving in free ſpace, and acted on by accelerating forces directed to different bodies?

The parabola (conical) is the moſt ſimple of all the lines of unequably varying curvature, and becomes a very good ſtandard of compariſon. In the parabola ABC (fig. 8.) let the parameter be $2a$. The equation is then $2ax = y^2$; $DE = a$; p, or $BE = \sqrt{a^2+y^2}$ $DQ = a + 2x$ (by what was formerly demonſtrated). Moreover, $DB : BE = DQ : BN$; and $BN = \frac{pa+2px}{a}$, $= r$. Theſe equations give $2a\dot{x} = 2y\dot{y}, = 2p\dot{p}$; and $\frac{a\dot{p}+2x\dot{p}+2p\dot{x}}{a} = \dot{r}$. Now making $\dot{x} = 1$, and reducing the equations, we obtain $\dot{y} = \frac{a}{y}$; $\dot{p} = \frac{y\dot{y}}{p}, = \frac{a}{p}$; and $\dot{r} = \frac{a\dot{p}+2x\dot{p}+2p}{a}$.

With theſe values of $\dot{y}, \dot{p}, \dot{r}$, we obtain a numerical value of $\frac{y\dot{r}}{p}$ moſt readily. Thus, in order to obtain the index of variation of curvature in the point where the ordinate at the focus cuts the parabola, make $a = 1$. Then $2x = y^2$; $x = \frac{1}{2}$, $y\ (= \sqrt{2x}) = 1$; $\dot{y}\left(= \frac{a}{y}\right) = 1$; $p\ (= \sqrt{a^2+y^2}) = \sqrt{2}$; $\dot{p}\left(= \frac{a}{p}\right) = \sqrt{\frac{1}{2}}$, and $\dot{r}\left(= \frac{a\dot{p}+2x\dot{p}+2p}{a}\right) = \sqrt{2} \times 3$. Therefore $\frac{y\dot{r}}{p} = 3, =$ the index of variation in the point B when D is the focus of the parabola; that is to ſay, the fluxion of the radius of curvature is three times the fluxion of the curve.

The index of variation, where the ordinate is equal to the parameter, is had by making $x = 2$. This gives $y = 2$; $\dot{y} = \frac{1}{2}$; $p = \sqrt{5}$; $\dot{p} = \sqrt{\frac{1}{5}}$, and $\dot{r} = 3\sqrt{5}$. Wherefore $\frac{y\dot{r}}{p} = 6$, which is the index of variation. Moreover, ſince p and $\dot{r}$ are in a conſtant ratio, it appears that the index of variation of curvature in the parabola is proportional to the ordinate y. It is always $= 6\,\frac{\text{ordinate}}{\text{parameter}}$; and thus, with very little trouble, we can deſcribe the evolute of its evolute, *i. e.* of the ſemicubical parabola.

In like manner, it may be ſhewn, that in all the conic ſections $\frac{\dot{r}}{\dot{z}}$ is always proportional to the rectangle of the ordinate DB and the ſubnormal DE, or to DB × DE. In the parabola, whoſe equation is $2ax = y^2$, we have $\frac{\dot{r}}{\dot{z}} = \frac{3y}{a}$. In an ellipſe, whoſe equation is $2ax - bx^2 = y^2$, we have $\frac{\dot{r}}{\dot{z}} = \frac{3-3b}{a} \times DB \times DE$, and in the hyperbola, whoſe equation is $2ax + bx^2$, $\frac{\dot{r}}{\dot{z}}$ is $= \frac{2+3b}{a} \times DB \times DE$. This ratio, in all the three ſections, is always as the tangent of the angle contained between the diameter and the normal at the point of contact. By this we may compare them with a parabola. In the cycloid at the point E (fig. 5.) $\frac{\dot{r}}{\dot{z}}$ is $= \tan. \angle EKM$, &c. &c.

All theſe things may be traced in the obſervations made on fig. 11. and 12. When the angle BEΓ is a right angle, the angle KBQ indicates it directly, its tangent being always $= \frac{2\dot{r}}{3\dot{z}}$. It is eaſy alſo to ſee, that when the curve EMH is a parabola, the line BKF is a ſtraight line parallel to EΓ. It is alſo plain, that by the ſame ſteps that we proved that no circle can paſs between this parabola and its equicurve circle ERB, ſo no other parabola can paſs between them. Indeed the ſame reaſoning will prove that no curve of the ſame kind can paſs between any curve and its oſculating circle. In many caſes, it is more eaſy to reaſon from the curvature of a curve, by comparing it with an equicurve parabola than with an equicurve circle; particularly in treating of the curvilineal motions of bodies in free ſpace, actuated by deflecting forces.

If EMH be an ellipſe or hyperbola, BKF is another ellipſe or hyperbola (*M'Laurin*, § 373.)

We have thus endeavoured to introduce our readers into this curious branch of ſpeculative geometry. An introduction is all that can be expected from a work of this kind. We have enlarged on particular points, in proportion as we thought that the notions entertained on the ſubject were inadequate, or even vague and indiſtinct; and we hope that ſome may be incited to acquire clearer conceptions by going to the fountain head. We conclude, by recommending to the young geometer the peruſal of the Fluxions of Sir Iſaac Newton, after he has read M'Laurin's Chapter with care. He will probably be ſurpriſed and delighted with ſeeing the whole compreſſed by a maſter's hand into ſuch narrow compaſs with ſuch beautiful perſpicuity.

JOAN D' ARC, the maid of Orleans, has been variouſly characteriſed; but all now agree, that ſhe was worthy of a better fate than the horrid death ſhe was doomed to die. (See JOAN *d'Arc*, *Encycl.*). But did ſhe actually die that death? An ingenious writer in the *Monthly Magazine* has proved, we think, that ſhe did not.

The biſhop of Beauvais (ſays he) is accuſed by all parties of treachery and trick in the conduct of the trial: it was his known propenſity to gain his ends by ſtratagem, craft, manœuvre, fraud, dexterity. He ſeeks out, and brings forward, ſuch teſtimony only as relates to eccleſiaſtical offences, and then hands over the deciſion to the ſecular judges, whoſe clemency he invokes. Joan ſays to him publicly, "You * *promiſed* to reſtore me to the church, and you deliver me to my enemies." The intention of the biſhop, then, muſt have been, that the ſecular judges, for want of evidence, ſhould ſee no offence againſt the ſtate; as the clerical judges, notwithſtanding the evidence, had declined to ſee any againſt the church. A fatal ſentence was, however, pronounced; and the fulfilment of it entruſted to the eccleſiaſtical authorities. Immediately after the *auto da fé*, one of the executioners ran to two friars, and ſaid, "that he had never been ſo ſhocked at any execution, and that the Engliſh had built up † a ſcaffolding of plaſter (*un echafaud de platre*) ſo lofty, that he could not approach the culprit, which muſt have cauſed her ſufferings to be long and horrid." She was, therefore, by ſome *unuſual* contrivance, kept out of the reach and obſervation even of the executioners.

Some time after, when public commiſeration had ſucceeded to a vindictive bigotry, a woman appeared at Metz ‡, who declared herſelf to be Joan of Arc. She was everywhere welcomed with zeal. At Orleans, eſpecially, where Joan was well known, ſhe was received with the honours due to the liberatreſs of the town. She was acknowledged by both her brothers, Jean and Pierre d'Arc. On their teſtimony ſhe was married by a gentleman of the houſe of Amboiſe, in 1436. At their ſolicitation her ſentence was annulled in 1456. The Pariſians, indeed, long remained incredulous: they muſt elſe have puniſhed thoſe eccleſiaſtics, whoſe humanity, perhaps, conſpired with the biſhop of Beauvais to withdraw her from real execution down a central chimney of brick and mortar; or, as the executioner called it, a ſcaffolding of plaſter. The king, for the woman ſeems to have ſhunned no confrontation, is ſtated to have received her with theſe words: "*Pucelle, m'amie, ſoyez la tres bien revenue, au nom de Dieu.*" She is then ſaid to have communicated to him, kneeling, the artifice practiſed. Can this woman be an impoſtor? Our author thinks not, and appeals to Voltaire, who, in his proſe works, ſeems willing to allow that ſhe was not, as is too commonly imagined, one of thoſe half-inſane enthuſiaſts, employed as tools to work upon the vulgar; whom the one party endeavoured to cry up as a propheteſs, and the other to cry down as a witch; but that ſhe was a real heroine, ſuperior to vulgar prejudice, and no leſs remarkable by force of mind than for a courage and ſtrength unuſual in her ſex. This opinion is certainly countenanced by her behaviour in adverſity, and during her trial, which was firm without inſolence, and exalted without affectation.

* *Villaret Hiſtoire de France*, tom. xv. p. 72.

† *Paſquier Hiſtoire d'Orleans*, liv. vi.

‡ *Hiſtoire de la Pucelle par l'Abbé Lenglet* See alſo *Mélanges Curieux Monſtrelet*; and the manuſcript authorities cited by the continuator of Velly.

JONES (Sir William), who was ſtyled by Johnſon the moſt enlightened of men, was the ſon of William Jones, Eſq; one of the laſt of thoſe genuine mathematicians, admirers, and contemporaries of Newton, who cultivated and improved the ſciences in the preſent century. Our author was born on the 28th of September 1746, and received his education at Harrow ſchool, under the care of Dr Robert Sumner, whom he has celebrated in an eulogium which will out-laſt braſs or marble. We are told that he was a claſs-fellow with Dr Parr, and at a very early age diſplayed talents which gave his tutor the moſt promiſing expectations, and which have ſince been amply juſtified. From Harrow he was ſent to Univerſity college, Oxford, where the rapidity and elegance of his literary acquiſitions excited general admiration; while a temper, ardently generous, and morals perfectly irreproachable, procured him teſtimonies of the moſt valuable eſteem. The grateful affection which he always cheriſhed for that venerable ſeat of learning, did as much honour to his ſenſibility, as Oxford herſelf has received by enrolling him among the number of her ſons.

In the twenty-third year of his age he travelled through France, and reſided ſome time at Nice, where he employed himſelf very differently from moſt other young men who make what is called the tour of Europe. *Man*, and the influence of various forms of *government*, were the principal objects of his inveſtigation; and in applying the reſult of his inquiries to the ſtate of his own country, he mingled the ſolicitudes of the Patriot with the honeſt partialities of an Engliſhman.

Mr Jones's firſt literary work was a tranſlation into French of a Perſian manuſcript, entitled "*Hiſtoire de Nadir Shah, connu ſous le nom de Thahmas Kuli Khan, Empereur de Perſe*," in two vols. 4to; the hiſtory of which performance we ſhall give in his own words: "A great northern monarch, who viſited this country a few years ago, under the name of the Prince of Travendal, brought with him an eaſtern manuſcript, containing the life of Nadir Shah, the late ſovereign of Perſia, which he was deſirous of having tranſlated in England. The ſecretary of ſtate, with whom the Daniſh miniſter had converſed upon the ſubject, ſent the volume to me, requeſting me to give a literal tranſlation of it in the French language; but I wholly declined the taſk, alledging for my excuſe the length of the book, the dryneſs of the ſubject, the difficulty of the ſtyle, and chiefly my want both of leiſure and ability to enter upon an undertaking ſo fruitleſs and ſo laborious. I mentioned, however, a gentleman, with whom I had not then the pleaſure of being acquainted, but who had diſtinguiſhed himſelf by a tranſlation of a Perſian hiſtory, and was far abler than myſelf to ſatisfy the king of Denmark's expectations. The learned writer, who had other works upon his hands, excuſed himſelf on the account of his many engagements; and the application to me was renewed. It was hinted, that my compliance would be of no ſmall advantage to me at my entrance into life; that it would procure me ſome mark of diſtinction which might be pleaſing to me; and, above all, that it would be a reflection upon this country, if the king ſhould be obliged to carry the manuſcript into France. Incited by theſe motives, and principally by the laſt of them, unwilling to be thought churliſh or moroſe, and eager for the bubble reputation, I undertook the work, and ſent a ſpecimen of it to his Daniſh Majeſty; who returned his approbation of the ſtyle and method, but deſired that the whole tranſlation might be perfectly literal, and the oriental images accurately preſerved. The taſk would have been far eaſier to me, had I been directed to finiſh it in Latin; for the acquiſition of a French ſtyle was infinitely more tedious; and it was neceſſary to have every chapter corrected by a native of France, before it could be offered to the diſcerning eye of the public, ſince in every language there are certain peculiarities of idiom, and nice ſhades of meaning, which a foreigner can never learn to perfection. But the work, how arduous and unpleaſing ſoever, was completed in a year, not without repeated hints from the ſecretary's office that it was expected with great impatience by the Court of Denmark." The tranſlation of the Hiſtory of Nadir Shah was publiſhed in the ſummer of the year 1770, at the expence of the tranſlator; and forty copies upon large paper were ſent to Copenhagen; one of them bound with uncommon elegance for the king himſelf, and the others as preſents to his courtiers*.

What marks of diſtinction our author received, or what fruits he reaped for his labour, he has not thought proper to diſcloſe; but if any dependence is to be placed on common fame, the reward beſtowed upon him for this laborious taſk conſiſted only in the thanks of his Daniſh Majeſty, and the honour of being enrolled in the Royal Society of Copenhagen. That diſtinction was indeed accompanied with a letter, recommending the learned tranſlator to the patronage of his own ſovereign; but, in the interim, his friend Lord Dartmouth, who was to have delivered it, had reſigned his office of ſecretary of ſtate, and the letter, we are told, was never preſented.

There is reaſon to think, that this early and ſevere diſappointment made a deep impreſſion on his mind, and induced him to renounce the muſes for a time, and to apply himſelf with aſſiduity to the ſtudy of juriſprudence. This we think apparent, from the ſtyle in which he writes of his return from the continent, and of the death of his beloved preceptor Dr Sumner.

"When I left Nice, (ſays he) where I had reſided near ſeven months, and after traverſing almoſt all France, returned to England, I moſt ardently deſired to paſs ſeveral years more in the ſtudy of polite literature; as then, I thought, I might enter into public life, to which my ambition had always prompted me, more mature and prepared: but with this fruit of my leiſure, either fortune, or rather Providence, the diſpoſer of all human events, would not indulge my ſloth; for on a ſudden, I was obliged to quit that very literature to which, from my childhood, I had applied myſelf; and he who had been the encourager and aſſiſtant of my ſtudies, who had inſtructed, taught, formed me ſuch as I was, or if I am any thing at all, ROBERT SUMNER, within a year after my return, was ſnatched away by an untimely death (A)."

In 1771 Mr Jones publiſhed *Diſſertation ſur la Literature Orientale*, 8vo, and this was followed by *Lettre à Monſieur* A** Du P***, *dans laquelle eſt compris l'Examen de ſa Traduction des Livres attribues à Zoroaſtre*, 8vo. The diſſertation offered a favourable ſpecimen of the author's abilities as a linguiſt and as a critic; and the letter contained a ſpirited vindication of the univerſity of Oxford, from the very ſcurrilous reproaches, in which its incompetency in Oriental literature was aſſerted by the illiberal tranſlator of the ſuppoſed works of the Perſian philoſopher.

In the ſame year he gave to the public, "A Grammar of the Perſian language," 4to, and at the ſame time propoſed to republiſh Meninſki's Dictionary, with improvements from *De Labroſſe's Gazophylacium Linguæ Perſarum*, and to add in their proper place an Appendix ſubjoined to Gehanaguire's Perſic Dictionary. The Grammar has been found extremely uſeful, and has

* *Preface to the Hiſtory of Nadir Shah*, 1773.

(A) As a ſpecimen of our author's latinity, we ſubjoin the epitaph on Dr Sumner, which is affixed to the wall of the ſouth tranſept of Harrow church.

H. S. E.
ROBERTUS SUMNER, S. T. P.
Collegii Regalis apud Cantab. olim Socius,
Scholæ Harrovienſis haud ita pridem Archididaſcalus.
Fuit hoc præſtantiſſimo Viro
Ingenium naturâ peracre, optimarum diſciplinis artium ſedulo
Excultum, uſu diuturno confirmatum, & quodammodo ſubactum.
Nemo enim aut in reconditis ſapientiæ ſtudiis illo ſubtilior extitit,
Aut humanioribus literis limatior: nemini fere vel felicius
Contigit judicii acumen, vel uberior eruditionis copia.
Egregiis hiſce cum dotibus naturæ, tum doctrinæ ſubſidiis,
Inſuper accedebat in ſcriptis mira ac prope perfecta eloquentia.
In ſermone facetiarum lepor plane Atticus, & gravitate ſuaviter
Aſpera urbanitas; in moribus ſingularis quædam integritas & fides;
Vitæ denique ratio conſtans ſibi, & ad virtutis normam diligenter ſevereque,
Exculta. Omnibus qui vel amico eſſent eo, vel magiſtro uſi, doctrinæ,
Ingenii, virtutis triſte reliquit deſiderium, ſubitâ, eheu! atque immaturâ
Morte correptus prid. Id. Sept. A. D.
1771, Æt. 41.

has been reprinted ſeveral times; but the deſign of the Dictionary, though an object of even national importance, for want of due encouragement was obliged to be laid aſide.

In 1772 he publiſhed "Poems; conſiſting chiefly of Tranſlations from the Aſiatic Languages. To which are added two Eſſays; 1. On the Poetry of the Eaſtern Nations. 2. On the Arts commonly called Imitative," 8vo, which in 1777 he republiſhed with the addition of ſome Latin Poems, every way worthy of their author. On the 18th June 1773, he took the degree of Maſter of Arts, and the ſame year publiſhed "The Hiſtory of the Life of Nadir Shah, King of Perſia. Extracted from an Eaſtern Manuſcript, which was tranſlated into French by order of his Majeſty the King of Denmark. With an Introduction, containing, 1. A Deſcription of Aſia according to the Oriental Geographers. 2. A ſhort Hiſtory of Perſia from the earlieſt Times to the preſent Century: And an Appendix, conſiſting of an Eſſay on Aſiatic Poetry, and the Hiſtory of the Perſian Language. To which are added Pieces relative to the French Tranſlation," 8vo. Our author having at this period determined to ſtudy the law as a profeſſion, and to relinquiſh every other purſuit, our readers will not be diſpleaſed with the following extract, relating to this reſolution, which concludes the preface to the hiſtory now under conſideration:

"To conclude; if any eſſential miſtakes be detected in this whole performance, the reader will excuſe them, when he reflects upon the great variety of dark and intricate points which are diſcuſſed in it; and if the obſcurity of the ſubject be not a ſufficient plea for the errors which may be diſcovered in the work, let it be conſidered, to uſe the words of Pope in the preface to his juvenile poems, that there are very few things in this collection which were not written under the age of five-and-twenty: moſt of them indeed were compoſed in the intervals of my leiſure in the South of France, before I had applied myſelf to a ſtudy of a very different nature, which it is now my reſolution to make the ſole object of my life. Whatever then be the fate of this production, I ſhall never be tempted to vindicate any part of it which may be thought exceptionable; but ſhall gladly reſign my own opinions, for the ſake of embracing others, which may ſeem more probable; being perſuaded, that nothing is more laudable than the love of truth, nothing more odious than the obſtinacy of perſiſting in error. Nor ſhall I eaſily be induced, when I have diſburdened myſelf of two other pieces which are now in the preſs, to begin any other work of the literary kind; but ſhall confine myſelf wholly to that branch of knowledge in which it is my chief ambition to excel. It is a painful conſideration, that the profeſſion of literature, by far the moſt laborious of any, leads to no real benefit or true glory whatſoever. Poetry, ſcience, letters, when they are not made the ſole buſineſs of life, may become its ornaments in proſperity, and its moſt pleaſing conſolation in a change of fortune; but if a man addicts himſelf entirely to learning, and hopes by that, either to raiſe a family, or to acquire, what ſo many wiſh for, and ſo few ever attain, an honourable retirement in his declining age, he will find, when it is too late, that he has miſtaken his path; that other labours, other ſtudies, are neceſſary; and that unleſs he can aſſert his own independence in active life, it will avail him little to be favoured by the learned, eſteemed by the eminent, or recommended even by kings. It is true, on the other hand, that no external advantages can make amends for the loſs of virtue and integrity, which alone give a perfect comfort to him who poſſeſſes them. Let a man, therefore, who wiſhes to enjoy, what no fortune or honour can beſtow, the bleſſing of ſelf-approbation, aſpire to the glory given to Pericles by a celebrated hiſtorian, of being acquainted with all uſeful knowledge, of expreſſing what he knows with copiouſneſs and freedom, of loving his friends and country, and of diſdaining the mean purſuits of lucre and intereſt: this is the only career on which an honeſt man ought to enter, or from which he can hope to gain any ſolid happineſs."

The next year he publiſhed *Poeſeos Aſiaticæ Commentariorum Libri Sex, cum Appendice; ſubjicitur Limon, ſeu Miſcellaneorum Liber*, 8vo; and purſuing his purpoſe of applying to the ſtudy of the law, we hear no more of him from the preſs (except the new edition of his Poems), until the year 1779. In this interval he was called to the bar, and attended Weſtminſter-hall and the Oxford circuit, where he obtained but little buſineſs. He was however appointed a commiſſioner of bankrupts by Lord Bathurſt, who is ſuppoſed to have intended to exert his intereſt to procure his nomination to the bench in the Eaſt Indies.

He publiſhed in this year, "The ſpeeches of Iſæus, in cauſes concerning the law of ſucceſſion to property at Athens; with a preparatory diſcourſe, notes critical and hiſtorical, and a Commentary, 4to." In this valuable work, the talents of the ſcholar, the critic, and the lawyer, combine to elucidate a very important part of juriſprudence; for, "though deep reſearches into the legal antiquities of *Greece* and *Rome* (as he obſerves in his Commentary) are of greater uſe to ſcholars and contemplative perſons, than to lawyers and men of buſineſs; though Bracton and Lyttleton, Coke and Rolle, are the proper objects of our ſtudy; yet the ableſt advocates, and wiſeſt judges, have frequently embelliſhed their arguments with learned alluſions to antient caſes; and ſuch alluſions, it muſt be allowed, are often uſeful, always ornamental; and, when they are introduced without pedantry, never fail to pleaſe." The work was dedicated in a ſtyle of reſpectful gratitude to his patron Lord Bathurſt.

In the year 1780, we find our author a candidate to repreſent in parliament the univerſity of Oxford. He had for ſome time reſided but little in the univerſity, and therefore laboured under ſome diſadvantages; but he did not meanly court the ſupport of any man. In a paper, which was circulated on that occaſion, his friends, who were numerous, declare, that they have "neither openly ſolicited, nor intend openly to ſolicit, votes for Mr Jones within the Univerſity itſelf, becauſe he will never become the inſtrument of diſturbing the calm ſeat of the Muſes, by conſenting to any ſuch ſolicitation for himſelf or for any man whatever. His own applications have been, are, and will be, confined to thoſe only who have profeſſed a regard for him, *and who have no votes themſelves*; the Maſters of Arts in a great univerſity, whoſe prerogative is cool reaſon and impartial judgment, muſt never be placed on a level with the voters of a borough, or the freeholders of a county. Even in proceeding thus far, he does not ſet the example, but follows it; and his friends would never have printed any paper, if they had not thought themſelves juſtified by the conduct of others.

"For the firſt and the laſt time, they beg leave to ſuggeſt, that no exertions muſt be ſpared by thoſe who, either perſonally or by reputation, approve the character of Mr Jones; into which, both literary and political, as well as moral, his friends deſire and demand the ſtricteſt ſcrutiny. For his univerſity he began early to provoke, and poſſibly to incur, the diſpleaſure of great and powerful men: For his univerſity he entered the liſts with a foul-mouthed and arrogant Frenchman, who had attacked Oxford in three large volumes of miſrepreſentation and ſcurrility: For his univerſity he reſigned, for a whole year, his favourite ſtudies and purſuits, to ſave Oxford the diſcredit of not having one of her ſons ready to tranſlate a tedious Perſian manuſcript. To Oxford, in ſhort, he is known to be attached by the ſtrongeſt poſſible ties; and only regrets the neceſſity of abſenting himſelf from the place in which of all others he moſt delights, until the event of the preſent competition ſhall either convince him that he has toiled in vain as a man of letters, or ſhall confer on him the greateſt reward to which he can aſpire. The unavoidable diſadvantage of being ſo late propoſed, and the reſpectable ſupport with which he is now honoured, will ſecure him in all events from the leaſt diſgrace." The application was unſucceſsful, chiefly becauſe his own college had fixed upon another candidate, from a perſuaſion that the immediate appointment of Mr Jones to a ſeat, then vacant on the bench of judges in India, was morally certain.

The riots of that year gave occaſion to another publication of our author, entitled, "An Inquiry into the legal Mode of ſuppreſſing Riots; with a conſtitutional Plan of future Defence," 8vo; and in 1781 he publiſhed "An Eſſay on the Law of Bailments," 8vo, a very maſterly treatiſe, which did great honour to his legal abilities. In this laſt work he inculcates the neceſſity of deeply exploring the grounds of the common law; and ſpeaking of Blackſtone, (he ſays) "his commentaries are the moſt correct and beautiful outline that ever was exhibited of any human ſcience; but they alone will no more form a lawyer, than a general map of the world, how accurately and elegantly ſoever it may be delineated, will make a geographer."

In this year he likewiſe recalled his muſe in an Ode on the nuptials of Lord Viſcount Althorpe, who had been his pupil, to Miſs Lavinia Bingham. This beautiful little poem is preſerved in the European Magazine for January 1785, and we think in other periodical publications.

From many circumſtances which might be collected together, it would appear that our author at this juncture did not coincide in opinion with thoſe who had the direction of government, nor did he approve the meaſures at that period adopted.—With theſe ſentiments he ſeems to have been ſelected as a proper perſon to be introduced as a member of the Conſtitutional Society. Could he have foreſeen the degeneracy of ſuch aſſociations, there is reaſon to believe that he would have declined what he condeſcended to accept as an honour; for though an ardent friend to liberty, he was an enemy to theoretical innovation, and declares, in a letter to the ſecretary, that by the term conſtitution, he underſtands "the great ſyſtem of public, in contradiction to private and criminal law, which compriſes all thoſe articles which Blackſtone arranges, in his firſt volume, under the rights of perſons, and of which he gives a perſpicuous analyſis. Whatever then relates to the rights of perſons, either abſolute rights, as the enjoyment of liberty, ſecurity, and property, or relative, that is, in the public relations of magiſtrates and people, makes a part of that majeſtic whole, which we properly call the conſtitution. This conſtitutional or public law is partly unwritten, and grounded upon immemorial uſage, and partly written or enacted by the legiſlative power; but the unwritten, or common law, contains the true ſpirit of our conſtitution: the written has often moſt unjuſtifiably altered the form of it; the common law is the collected wiſdom of many centuries, having been uſed and approved by ſucceſſive generations; but the ſtatutes frequently contain the whims of a few leading men, and ſometimes of the mere individuals employed to draw them."

In 1782 he publiſhed "The Mahomedan Law of Succeſſion to the Property of Inteſtates, in Arabic, with a verbal Tranſlation and explanatory Notes." 4to.

At length the poſt of one of the judges in the Eaſt Indies, which had been kept vacant five years, was determined upon being filled up; and our author, on the 4th March 1783, was appointed to that ſtation, and on the 20th received the honour of knighthood. On the 8th of April he married Miſs Shipley, eldeſt daughter of the Biſhop of St Aſaph, and almoſt immediately embarked for the Indies. He had previouſly publiſhed "The Moallakat; or, Seven Arabian Poems, which were ſuſpended on the Temple at Mecca, with a Tranſlation and Arguments." 4to. To this it was intended to add a preliminary diſcourſe and notes.—The former to compriſe obſervations on the antiquity of the Arabian language and letters; on the dialects and characters of Himyar and Koraiſh, with accounts of ſome Himyarick poets; on the manners of the Arabs in the age immediately preceding that of Mahomed; on the temple at Mecca, and the Moallakat, or pieces of poetry ſuſpended on its walls or gate; laſtly, on the lives of the Seven Poets, with a critical hiſtory of their works, and the various copies or editions of them preſerved in Europe, Aſia, and Africa. The latter to contain authorities and reaſons for the tranſlation of controverted paſſages; to elucidate all the obſcure couplets, and exhibit or propoſe amendments of the text; to direct the reader's attention to particular beauties, or point out remarkable defects; and to throw light on the images, figures, and alluſions of the Arabian poets, by citations either from writers of their own country, or from ſuch of our European travellers as beſt illuſtrate the ideas and cuſtoms of Eaſtern nations. This diſcourſe and the notes have not yet appeared. At his departure for the eaſtern world, he left, in manuſcript, with his brother-in-law the Dean of St Aſaph, a little tract, entitled "The Principles of Government, in a Dialogue between a Scholar and a Peaſant." This celebrated dialogue being afterwards publiſhed by the Dean, and widely circulated by the ſociety for conſtitutional information, the Dean was proſecuted for publiſhing a libel, and, if our memory deceives us not, was found guilty.

Sir William Jones now dropt for ever all concern in party politics, and applied himſelf to purſuits more worthy of his talents. During his voyage to India, he conceived the idea of the Aſiatic Society, of which an account has been given under the title SOCIETIES (*Encycl.*), and of whoſe reſearches five volumes, replete with much curious information, are now before the public. But ardently as his mind was attached to general literature and ſcience, he was by no means inattentive to the profeſſional duties of his high ſtation. He had indeed, to uſe his own expreſſion, an "undiſſembled fondneſs for the ſtudy of juriſprudence *;" and in the character of a judge, diſplayed the profound knowledge and irreproachable integrity, which, before his promotion, pervaded his reaſonings as a lawyer, and governed his conduct as a man. Unfortunately the intenſe ardour of application, which produced his frequent contributions to the ſtock of human knowledge, added to the unfavourable influence of the climate, greatly impaired his health. On this account, after a reſidence of about fifteen years in India, he made preparations for returning to England; but death interpoſed; and this illuſtrious ornament of ſcience and virtue was taken from the world on the 27th of April 1794, in the 48th year of his age. "It is to the ſhame of ſcepticiſm (as one of his biographers well obſerves), to the encouragement of hope, and to the honour of genius, that this great man was a ſincere believer in the doctrines of Chriſtianity, and that he was found in his cloſet in the attitude of addreſſing his prayer to God." We ſhall give his character as it was drawn by Sir John Shore, Baronet, (now Lord Teignmouth) in a diſcourſe delivered at a meeting of the Aſiatic Society, held on the 22d of May 1794.

"His capacity for the acquiſition of languages has never been excelled. In Greek and Roman literature, his early proficiency was the ſubject of admiration and applauſe; and knowledge of whatever nature, once obtained by him, was ever afterwards progreſſive. The more elegant dialects of modern Europe, the French, the Spaniſh, and Italian, he ſpoke and wrote with the greateſt fluency and preciſion; and the German and Portugueſe were familiar to him. At an early period of life his application to Oriental literature commenced; he ſtudied the Hebrew with eaſe and ſucceſs; and many of the moſt learned Aſiatics have the candour to avow, that his knowledge of Arabic and Perſian was as accurate and extenſive as their own; he was alſo converſant in the Turkiſh idiom, and the Chineſe had even attracted his notice ſo far as to induce him to learn the radical characters of that language, with a view perhaps to farther improvements. It was to be expected, after his arrival in India, that he would eagerly embrace the opportunity of making himſelf maſter of the Sanſcrit; and the moſt enlightened profeſſors of the doctrines of Brahma confeſs with pride, delight, and ſurpriſe, that his knowledge of their ſacred dialect was moſt critically correct and profound. The Pandits, who were in the habit of attending him, could not, after his death, ſuppreſs their tears for his loſs, nor find terms to expreſs their admiration at the wonderful progreſs he had made in their ſciences.

"Before the expiration of his twenty-ſecond year, he had completed his Commentaries on the Poetry of the Aſiatics, although a conſiderable time afterwards elapſed before their publication; and this work, if no other monument of his labours exiſted, would at once furniſh proofs of his conſummate ſkill in the Oriental dialects, of his proficiency in thoſe of Rome and Greece, of taſte and erudition far beyond his years, and of talents and application without example.

"But the judgment of Sir William Jones was too diſcerning to conſider language in any other light than as the key of ſcience, and he would have deſpiſed the reputation of a mere linguiſt. Knowledge and truth were the objects of all his ſtudies, and his ambition was to be uſeful to mankind; with theſe views he extended his reſearches to all languages, nations, and times.

"Such were the motives that induced him to propoſe to the government of India, what he juſtly denominated a work of national utility and importance, the compilation of a copious Digeſt of Hindu and Mahomedan Law, from Sanſcrit and Arabic originals, with an offer of his ſervices to ſuperintend the compilation, and with a promiſe to tranſlate it. He had foreſeen, previous to his departure from Europe, that without the aid of ſuch a work, the wiſe and benevolent intentions of the legiſlature of Great Britain, in leaving to a certain extent the natives of theſe provinces in poſſeſſion of their own laws, could not be completely fulfilled; and his experience, after a ſhort reſidence in India, confirmed what his ſagacity had anticipated, that without principles to refer to, in a language familiar to the judges of the courts, adjudications amongſt the natives muſt too often be ſubject to an uncertain and erroneous expoſition, or wilful miſinterpretation of their laws.

"To the ſuperintendance of this work, which was immediately undertaken at his ſuggeſtion, he aſſiduouſly devoted thoſe hours which he could ſpare from his profeſſional duties. After tracing the plan of the Digeſt, he preſcribed its arrangement and mode of execution, and ſelected from the moſt learned Hindus and Mahomedans fit perſons for the taſk of compiling it: flattered by his attention, and encouraged by his applauſe, the Pandits proſecuted their labours with chearful zeal to a ſatisfactory concluſion. The Molavees have alſo nearly finiſhed their portion of the work; but we muſt ever regret, that the promiſed tranſlation, as well as the meditated preliminary diſſertation, have been fruſtrated by that decree, which ſo often intercepts the performance of human purpoſes.

"During the courſe of this compilation, and as auxiliary to it, he was led to ſtudy the works of Menu, reputed by the Hindus to be the oldeſt and holieſt of legiſlators; and finding them to compriſe a ſyſtem of religious and civil duties, and of law in all its branches, ſo comprehenſive and minutely exact, that it might be conſidered as the Inſtitutes of Hindu Law, he preſented a tranſlation of them to the government of Bengal. During the ſame period, deeming no labour exceſſive or ſuperfluous that tended in any reſpect to promote the welfare or happineſs of mankind, he gave the public an Engliſh verſion of the Arabic Text of the Sirajiyah or Mahomedan Law of Inheritance, with a Commentary. He had already (as has been obſerved) publiſhed in England a tranſlation of a tract on the ſame ſubject by another Mahomedan lawyer, containing, as his own words expreſs, 'a lively and elegant Epitome of the Law of Inheritance of Zaid.'

* *Law of Bailments.*

"To theſe learned and important works, ſo far out of the road of amuſement, nothing could have engaged his application but that deſire which he ever profeſſed, of rendering his knowledge uſeful to his nation, and beneficial to the inhabitants of theſe provinces.

"I ſhould ſcarcely (continues Lord Teignmouth) think it of importance to mention, that he did not diſdain the office of editor of a Sanſcrit and Perſian work, if it did not afford me an opportunity of adding, that the latter was publiſhed at his own expence, and was ſold for the benefit of inſolvent debtors. A ſimilar application was made of the produce of Sirajiyah."

But nothing exhibits the large graſp of Sir William Jones's mind in ſo ſtriking a point of view as a paper in his own hand-writing, which came into Lord Teignmouth's poſſeſſion after his death. It was intitled DESIDERATA, and propoſed for inveſtigation the following ſubjects relating to the eaſtern world.

India.—1. The ancient geography of India, &c. from the Puranas. 2. A botanical deſcription of Indian plants, from the Coſhas, &c. 3. A grammar of the Sanſcrit language, from Panini, &c. 4. A dictionary of the Sanſcrit language, from the 32 original vocabularies and Nirukti. 5. On the ancient muſic of the Indians. 6. On the medical ſubſtances of India, and the Indian art of medicine. 7. On the philoſophy of the ancient Indians. 8. A tranſlation of the Veda. 9. On ancient Indian geometry, aſtronomy, and algebra. 10. A tranſlation of the Puranas. 11. A tranſlation of the Mahabbara and Ramayan. 12. On the Indian theatre, &c. &c. 13. On the Indian conſtellations, with their mythology, from the Puranas. 14. The hiſtory of India before the Madomedan conqueſt, from the Sanſcrit Caſhmir Hiſtories.

Arabia.—15. The hiſtory of Arabia before Mahomed. 16. A tranſlation of the Hamaſa. 17. A tranſlation of Hariri. 18. A tranſlation of the Facahatul Khulaſa. Of the Caſiah.

Perſia.—19. The hiſtory of Perſia, from authorities in Sanſcrit, Arabic, Greek, Turkiſh, Perſian ancient and modern, Firdauſi's Khroſrau nama. 20. The five poems of Nizami, tranſlated in proſe. 21. A dictionary of pure Perſian Je changire.

China.—22. A tranſlation of Shi-cing. 23. The text of Can-fu-tſu, verbally tranſlated.

Tartary.—24. A hiſtory of the Tartar nations, chiefly of the Moguls and Othmans, from the Turkiſh and Perſian.

"We are not authoriſed (ſays his Lordſhip) to conclude, that he had himſelf formed a determination to complete the works which his genius and knowledge had thus ſketched; the taſk ſeems to require a period beyond the probable duration of any human life; but we, who had the happineſs to know Sir William Jones; who were witneſſes of his indefatigable perſeverance in the purſuit of knowledge, and of his ardour to accompliſh whatever he deemed important; who ſaw the extent of his intellectual powers, his wonderful attainments in literature and ſcience, and the facility with which all his compoſitions were made—cannot doubt, if it had pleaſed Providence to protract the date of his exiſtence, that he would have ably executed much of what he had ſo extenſively planned."

We have already enumerated attainments and works which, from their diverſity and extent, ſeem far beyond the capacity of the moſt enlarged minds; but the catalogue may yet be augmented. To a proficiency in the languages of Greece, Rome, and Aſia, he added the knowledge of the philoſophy of thoſe countries, and of every thing curious and valuable that had been taught in them. The doctrines of the Academy, the Lyceum, or the Portico, were not more familiar to him than the tenets of the Vedas, the myſticiſm of the Suſis, or the religion of the ancient Perſians; and whilſt, with a kindred genius, he peruſed with rapture the heroic, lyric, or moral compoſitions of the moſt renowned poets of Greece, Rome, and Aſia, he could turn with equal delight and knowledge to the ſublime ſpeculations or mathematical calculations of Barrow and Newton. With them alſo he profeſſed his conviction of the truth of the Chriſtian religion; and he juſtly deemed it no inconſiderable advantage, that his reſearches had corroborated the multiplied evidence of Revelation, by confirming the Moſaic account of the primitive world.

In his eighth anniverſary diſcourſe to the Aſiatic Society, he thus expreſſes himſelf: "Theological inquiries are no part of my preſent ſubject; but I cannot refrain from adding, that the collection of tracts which we call, from their excellence, the Scriptures, contain, independently of a divine origin, more true ſublimity, more exquiſite beauty, purer morality, more important hiſtory, and finer ſtrains both of poetry and eloquence, than could be collected within the ſame compaſs from all other books that were ever compoſed in any age, or any idiom. The two parts, of which the Scriptures conſiſt, are connected by a chain of compoſitions, which bear no reſemblance in form or ſtyle to any that can be produced from the ſtores of Grecian, Indian, Perſian, or even Arabian learning; the antiquity of theſe compoſitions no man doubts, and the unſtrained application of them to events long ſubſequent to their publication, is a ſolid ground of belief that they were genuine predictions; and conſequently inſpired."

There were, in truth, few ſciences in which he had not acquired conſiderable proficiency; in moſt, his knowledge was profound. The theory of muſic was familiar to him; nor had he neglected to make himſelf acquainted with the intereſting diſcoveries lately made in chemiſtry; "and I have heard him (ſays Lord Teignmouth) aſſert, that his admiration of the ſtructure of the human frame had induced him to attend for a ſeaſon to a courſe of anatomical lectures, delivered by his friend the celebrated Hunter."

His laſt and favourite purſuit was the ſtudy of botany, which he originally began under the confinement of a ſevere and lingering diſorder, which with moſt minds would have proved a diſqualification from any application. It conſtituted the principal amuſement of his leiſure hours. In the arrangements of Linnæus, he diſcovered ſyſtem, truth, and ſcience, which never failed to captivate and engage his attention; and from the proofs which he has exhibited of his progreſs in botany, we may conclude that he would have extended the diſcoveries in that ſcience.

It cannot be deemed uſeleſs or ſuperfluous to inquire by what arts or method he was enabled to attain to a degree of knowledge almoſt univerſal, and apparently beyond the powers of man, during a life little exceeding 47 years.

The faculties of his mind, by nature vigorous, were improved by conſtant exerciſe; and his memory, by habitual practice, had acquired a capacity of retaining whatever had once been impreſſed upon it. To an unextinguiſhed ardour for univerſal knowledge, he joined a perſeverance in the purſuit of it which ſubdued all obſtacles; his ſtudies began with the dawn, and, during the intermiſſions of profeſſional duties, were continued throughout the day; reflection and meditation ſtrengthened and confirmed what induſtry and inveſtigation had accumulated. It was a fixed principle with him, from which he never voluntarily deviated, not to be deterred by any difficulties that were ſurmountable from proſecuting to a ſucceſsful termination what he had once deliberately undertaken.

But what appeared more particularly to have enabled him to employ his talents ſo much to his own and the public advantage, was the regular allotment of his time, and a ſcrupulous adherence to the diſtribution which he had fixed; hence all his ſtudies were purſued without interruption or confuſion. He collected information, too, from every quarter; juſtly concluding, that ſomething might be learned from the illiterate, to whom he liſtened with the utmoſt candour and complacency.

Lord Teignmouth, addreſſing himſelf to the Aſiatic Society, ſays, "Of the private and ſocial virtues of our lamented Preſident, our hearts are the beſt records. To you who knew him, it cannot be neceſſary for me to expatiate on the independence of his integrity, his humanity, probity, or benevolence, which every living creature participated; on the affability of his converſation and manners, or his modeſt, unaſſuming deportment: nor need I remark, that he was totally free from pedantry, as well as from arrogance and ſelf-ſufficiency, which ſometimes accompany and diſgrace the greateſt abilities. His preſence was the delight of every ſociety, which his converſation exhilarated and improved; and the public have not only to lament the loſs of his talents and abilities, but that of his example.

"To him, as the founder of our inſtitution, and whilſt he lived its firmeſt ſupport, our reverence is more particularly due. Inſtructed, animated, and encouraged by him, genius was called forth into exertion, and modeſt merit was excited to diſtinguiſh itſelf. Anxious for the reputation of the Society, he was indefatigable in his own endeavours to promote it, whilſt he cheerfully aſſiſted thoſe of others. In loſing him, we have not only been deprived of our brighteſt ornament, but of the guide and patron, on whoſe inſtructions, judgement, and candour, we could implicitly rely." Though theſe are the ſentiments, not only of Lord Teignmouth, but, we believe, of every man of letters, we truſt there is ſtill left in Bengal a ſufficient love of letters and of ſcience to carry on the plan which was formed by the genius of Sir William Jones.

JONESIA, is a very handſome middling-ſized ramous tree, found in gardens about Calcutta. In the Sanſcrit it is called *As'óca*, and in the Bengaleſe *Ruſſuck*; but the name Joneſia was given to it by the Aſiatic Society, who conſecrated it to the memory of their firſt preſident Sir William Jones. It is thus deſcribed by Dr Roxburgh, a member of that ſociety:

"*Calyx*, two leaved; corol, one petaled, piſtil-bearing; baſe of the tube impervious; ſtamens long, aſcending; inſerted into the margin of a glandulous nectarial ring, which crowns the mouth of the tube, the uppermoſt two of which more diſtant; ſtyle declining. *Legume* turgid. *Trunk* erect, though not very ſtraight. *Bark* dark brown, pretty ſmooth. *Branches* numerous, ſpreading in every direction, ſo as to form a moſt elegant ſhady head. *Leaves* alternate, abruptly feathered, ſeſſile, generally more than a foot long; when young pendulous and coloured. *Leaflets* oppoſite, from four to ſix pair, the lowermoſt broad lanced, the upper lanced; ſmooth, ſhining, firm, a little waved, from four to eight inches long. *Petiole* common, round, and ſmooth. *Stipule* axillary, ſolitary; in fact a proceſs from the baſe of the common petiole, as in many of the graſſes and monandriſts, &c. *Umbels* terminal and axillary; between the ſtipule and branchlet, globular, crowded, ſubſeſſile, erect. *Bracts*, a ſmall hearted one under each diviſion of the umbel. *Peduncle* and pedicles ſmooth, coloured. *Flowers* very numerous, pretty large; when they firſt expand they are of a beautiful orange colour, gradually changing to red, forming a variety of lovely ſhades; fragrant during the night. *Calyx* perianth, below two-leaved, leaflets ſmall, nearly oppoſite, coloured, hearted, bract-like, marking the termination of the pedicel, or beginning of the tube of the corol. *Corol* one-petalled, funnel-form; tube ſlightly incurved, firm, and fleſhy, tapering towards the baſe (club funnel-ſhaped) and there impervious; border four parted; diviſion ſpreading, ſuborbicular; margins moſt ſlightly woolly: one third the length of the tube. *Nectary*, a ſtimeniferous and piſtiliferous ring crowns the mouth of the tube. *Stamens*, filaments generally ſeven; and ſeven muſt, I think, be the natural number; viz. three on each ſide, and one below, above a vacancy, as if the place of an eighth filament, and is occupied on its inſide by the piſtil; they are equal, diſtinct, aſcending, from three to four times longer than the border of the corol. *Anthers* uniform, ſmall, incumbent. *Piſtil*, germ oblong, pediceled; pedicel inſerted into the inſide of the nectary, immediately below the vacant ſpace already mentioned; ſtyle nearly as long as the ſtamens, declining; ſtigma ſimple. *Pericarp*, legume ſcimeter-formed, turgid, outſide reticulated, otherwiſe pretty ſmooth; from ſix to ten inches long, and about two broad. *Seeds* generally from four to eight, ſmooth; grey, ſize of a large cheſnut."

The Joneſia flowers at the beginning of the hot ſeaſon, and its ſeeds ripen during the rains. The plants and ſeeds were originally brought to Calcutta from the interior parts of the country, where it is indigenous. *N. B.* Many of the flowers have only the rudiment of a piſtil. In Plate XXX. A is a branchlet of the natural ſize. B, A ſingle flower a little magnified; *a a* the calyx. C, A ſection of the ſame, exhibiting four of the ſtamens, 1 1 1 1 the piſtil 2, and how far the tube is perforated. D, A ſimilar ſection of one of the abortive flowers; 3 is the abortive ſiſtil. E, The ripe legume opening near the baſe, natural ſize. *Note*, The ſpace between the *b* and *c* marks the original tube of the coral. F, One of the ſeeds, natural ſize. G, The baſe of the common petiole, with its ſtipule; *a a*, the petioles of the lower pair of leaflets.

JOOTSI-SIMA, a ſmall flat iſland, which is ſeparated from Cape Nota in Japan by a channel about five leagues wide. Its circumference does not exceed two leagues; it is well wooded, of an agreeable aſpect, and well inhabited. Perouſe, who failed round it, remarked from the quarter-deck of his ſhip ſome conſiderable edifices between the houſes of the inhabitants; and hard by a fort of caſtle, at the ſouth-weſt point of the iſland, he diſtinguiſhed ſome gibbets. He does not, however, affirm that thoſe gibbets were for the execution of criminals; for, as he obſerves, it would be ſingular enough if the Japaneſe, whoſe cuſtoms are ſo different from ours, were in this point to reſembles us ſo nearly. He repreſents the iſland as ſurrounded with dreadful breakers; at the diſtance of a league and a half from which, he had conſtantly 60 fathoms, with rocky bottom. He places the iſland (differently, according to the editor of his voyage, from all other geographers) in latitude 37° 51′ north, and, in Long. 135° 20′ eaſt from Paris.

JOURNALS, the title of periodical publications. See *Encyclopædia*. The principal Britiſh Journals are: *The Hiſtory of the Works of the Learned*, begun at London in 1699. *Cenſura Temporum*, in 1708. About the ſame time there appeared two new ones; the one under the title of *Memoirs of Literature*, containing little more than an Engliſh tranſlation of ſome articles in the foreign Journals, by M. de la Roche; the other, a collection of looſe tracts, intitled, *Bibliotheca Curioſa*, or a Miſcellany. Theſe, however, with ſome others, are now no more, but are ſucceeded by the *Annual Regiſter*, which began in 1758; the *New Annual Regiſter*, begun in 1780; the *Monthly Review*, which began in the year 1749, and gives a character of all Engliſh literary publications, with the moſt conſiderable of the foreign ones: the *Critical Review*, which began in 1756, and is nearly on the ſame plan: as alſo the *London Review*, by Dr Kenrick, from 1775 to 1780; *Maty's Review*, from Feb. 1782 to Aug. 1786; the *Engliſh Review*, begun in Jan. 1783; and the *Analytical Review*, begun in May 1788, dropt in 1798, and revived in 1799, under the title of the *New Analytical Review*; but again dropt after two or three months trial: the *Britiſh Critic*, begun in 1792, and ſtill carried on with much ſpirit and ability: the *Anti-Jacobin Review and Magazine*, commenced in 1798, for the meritorious purpoſe of counteracting the pernicious tendency of French principles in politics and religion: the *New London Review*, January 1799: *A Journal of Natural Philoſophy, Chemiſtry, and the Arts*, which was begun in 1797 by Mr Nicholſon, and has been conducted in ſuch a manner, that it is one of the moſt valuable works of the kind to be found in any language: the *Philoſophical Magazine*, begun in 1798 by Mr Tilloch, and carried on upon much the ſame plan, and with much the ſame ſpirit, as Nicholſon's Journal.

Beſides theſe, we have ſeveral monthly pamphlets, called *Magazines*, which, together with a chronological ſeries of occurrences, contain letters from correſpondents, communicating extraordinary diſcoveries in nature and art, with controverſial pieces on all ſubjects. Of theſe, the principal are thoſe called the *Gentleman's Magazine*, which began with the year 1731; the *London Magazine*, which began a few months after, and has lately been diſcontinued; the *Univerſal Magazine*, which is nearly of as old a date; the *Scotch Magazine*, which began in 1739, and is ſtill continued; the *European Magazine*; and the *Monthly Magazine*, a miſcellany of much information, but not of good principles.

JOYST or Jeyst, the ſecond month of the Bengal year.

IRRATIONAL Numbers or *Quantities*, are the ſame as *ſurds*, for which ſee Algebra, *Encycl.*

IRREDUCIBLE Case, in algebra, is uſed for that caſe of cubic equations where the root, according to Cardan's rule, appears under an impoſſible or imaginary form, and yet is real.

It is remarkable that this caſe always happens, *viz.* one root, by Cardan's rule, in an impoſſible form, whenever the equation has three real roots, and no impoſſible ones, but at no time elſe.

If we were poſſeſſed of a general rule for accurately extracting the cube root of a binomial radical quantity, it is evident we might reſolve the irreducible caſe generally, which conſiſts of two of ſuch cubic binomial roots. But the labours of the algebraiſts, from Cardan down to the preſent time, have not been able to remove this difficulty. Dr Wallis thought that he had diſcovered ſuch a rule; but, like moſt others, it is merely tentative, and can only ſucceed in certain particular circumſtances.

IRON, is by much the moſt uſeful of all the metals, as has been ſufficiently proved under the article Iron, *Encycl.* and under Chemistry in this *Supplement*. The word is again introduced here, becauſe it affords us an opportunity of laying before our readers ſome valuable obſervations by Chaptal on the uſe of the *oxyds* of iron in dyeing cotton.

"The oxyd of iron has ſuch an affinity for cotton thread, that if the latter be plunged in a ſaturated ſolution of iron in any acid whatever, it immediately aſſumes a chamoy yellow colour, more or leſs dark, according to the ſtrength of the liquors. It is both a curious and eaſy experiment, that when cotton is made to paſs through a ſolution of the ſulphat of iron, rendered turbid by the oxyd which remains ſuſpended in the liquor, it will be ſufficient to dip the cotton in the bath to catch the laſt particle of the oxyd, and to reſtore to the liquor the tranſparency it has loſt. The ſolution, then, which before had a yellowiſh appearance, becomes more or leſs green, according as it is more or leſs charged.

"The colour given to cotton by the oxyd of iron becomes darker, merely by expoſure to the air; and this colour, ſoft and agreeable when taken from the bath, becomes harſh and ochry by the progreſſive oxydation of the metal. The colour of the oxyd of iron is very faſt: it reſiſts not only the air and water, but alſo alkaline leys, and ſoap gives it ſplendour without ſenſibly diminiſhing its intenſity. It is on account of theſe properties that the oxyd of iron has been introduced into the art of dyeing, and been made a colouring principle of the utmoſt value.

"In order that the oxyd of iron may be conveniently applied to the cotton thread, it is neceſſary to begin by effecting its ſolution; and, in this caſe, acids are employed as the moſt uſeful ſolvents. Dyers almoſt everywhere make a myſtery of the acid which they employ; but it is always the acetous, the ſulphuric, the nitric, or the muriatic. Some of them aſcribe great differences to the ſolution of iron by the one or the other acid; but, in general, they give the preference to the acetous. This predilection appears to be founded much leſs on the difference of the colours that may be communicated by the one or the other ſalt, than on the different degrees of corroſive power which each exerciſes on the ſtuff. That of the ſulphat and muriat is ſo great, that if the ſtuff be not waſhed when it comes from the bath, it will certainly be burnt; whereas ſolutions by the acetous, or any other vegetable acid, are not attended with the like inconvenience.

"Iron appears to be at the ſame degree of oxydation in the different acids, ſince it produces the ſame ſhade of colour when precipitated; and any acid ſolvent may be employed indiſcriminately, provided the nature of the ſalt, and the degree of the ſaturation of the acid, be ſufficiently known; for the ſubſequent operations may be then directed according to this knowledge, and the inconveniences which attend the uſe of ſome of theſe ſalts may be prevented. This, without doubt, is a great advantage which the man of ſcience enjoys over the mere workman, who is incapable of varying his proceſs according to the nature and ſtate of the ſalts which he employs.

"1. If the ſulphat of iron, or any other martial ſalt, be diſſolved in water, and cotton be dipped in the liquid, the cotton will aſſume a chamoy colour, more or leſs dark according as the ſolution is more or leſs charged. The affinity of the cotton to the iron is ſo great, that it attracts the metal, and takes it in a great meaſure from the acid by which it was diſſolved.

"2. If the iron of a pretty ſtrong ſolution be precipitated by an alkaline liquor that ſhews five or ſix degrees (by the areometer of Baumé), the reſult will be a greeniſh blue magma. The cotton macerated in this precipitate aſſumes at firſt an unequal tint of dirty green; but mere expoſure to the air makes it in a little time turn yellow, and the ſhade is very dark.

"It is by ſuch, or almoſt ſimilar proceſſes, that dyers communicate what is called among workmen an *ochre* or *ruſt colour*. But theſe colours are attended with ſeveral inconveniences to the artiſt: 1. Strong ſhades burn or injure the cloth: 2. This colour is harſh, diſagreeable to the eye, and cannot be eaſily united with the mild colours furniſhed by vegetables."

To avoid theſe inconveniences, our author made ſeveral attempts, which led him to the following practice: He treads the cotton cold in a ſolution of the ſulphat of iron, marking three degrees; he wrings it carefully, and immediately plunges it in a ley of potaſh at two degrees, upon which he has previouſly poured to ſaturation a ſolution of the ſulphat of alumine: the colour is then brightened, and becomes infinitely more delicate, ſoft, and agreeable. The ſulphat no longer attacks the tiſſue of the ſtuff; and after the cotton has been left in the bath for four or five hours, it is taken out to be wrung, waſhen, and dried. In this manner we may obtain every ſhade that can be wiſhed, by graduating the ſtrength of the ſolutions. This ſimple proceſs, the theory of which preſents itſelf to the mind of every chemiſt, has the advantage of furniſhing a colour very agreeable, exceedingly fixed, and, above all, extremely economical. He employs it with great advantage in dyeing nankeens, as it has the property of reſiſting leys. It becomes brown, however, by the action of aſtringents.

M. Chaptal made ſeveral attempts to combine this yellow with the blue of indigo, in order to obtain a durable green; but as they were all unſucceſsful, he infers that there is not a ſufficient affinity between the blue of indigo and the oxyds of iron. He found that theſe oxyds, on the other hand, combine very eaſily with the red of madder, and produce a bright violet or plum colour, the uſe of which is as extenſive as beneficial in the cotton manufactory. But if we ſhould confine ourſelves to apply theſe two colours to cotton, without having employed a mordant capable of fixing the latter, the colour would not only remain dull and diſagreeable by the impoſſibility of brightening it, but it would ſtill be attended with the great inconvenience of not reſiſting leys. We muſt begin, then, by preparing the cotton as if to diſpoſe it for receiving the Adrianople red; and when it has been brought to the operation of galling, it is to be paſſed through a ſolution of iron, more or leſs charged, according to the nature of the violet required: it is then to be carefully waſhed, twice maddered, and brightened in a bath of ſoap.

When a real velvety rich violet is required, it is not to be paſſed through the ſolution of iron till it has been previouſly galled; the iron is then precipitated in a bluiſh oxyd, which, combined with the red of madder, gives a moſt brilliant purple, more or leſs dark according to the ſtrength of the galling and of the ferruginous ſolution. It is very difficult to obtain an equal colour by this proceſs; and in manufactories, an equal violet is conſidered as a maſter-piece of art. It is generally believed, that it is only by well-directed manipulations that it is poſſible to reſolve this problem, of ſo much importance in dyeing. But I am convinced (ſays our author), that the great cauſe of the inequality in this dye is, that the iron depoſited on the cotton receives an oxydation merely by expoſure to the air, which varies in different parts of it. The threads which are on the outſide of the hank are ſtrongly oxydated, while thoſe in the inſide, removed from the action of the air, experience no change. It thence follows, that the inſide of the hank preſents a weak ſhade, while the exterior part exhibits a violet almoſt black. The means to remedy this inconvenience is, to waſh the cotton when it is taken from the ſolution of iron, and to expoſe it to the madder moiſt. The colour will become more equal and velvety. The ſolvents of iron are almoſt the ſame for this colour as for the yellow colour already mentioned.

The following obſervation may ſerve to guide the artiſt in brightening the violet on his cotton. The red of madder and the oxyd of iron depoſited on the ſtuff determine the violet colour. This colour becomes red or blue, according as either of the principles predominates. The dyer knows by experience how difficult it is to obtain a combination which produces the tone of colour deſired, eſpecially when it is required to be very full, lively, and durable. This object, however, may be obtained, not only by varying the proportions of the two colouring principles, but alſo by varying the proceſs of brightening. The only point is to be acquainted with the two following facts; that the ſoda deſtroys the iron, while the ſoap, by ſtrong ebullition, ſeizes in preference the red of the madder. Hence it is, that the colour may be inclined to red or blue, according as you brighten with one or the other of theſe mordants. Thus, cotton taken from the madder dye, when waſhed and boiled in the brightening liquor with $\frac{1}{10}$th of ſoap, will give a ſuperb violet; whereas you will obtain only a plum colour in treating it with ſoda.

The oxyd of iron precipitated on any ſtuff unites alſo very advantageouſly with the fawn colour furniſhed by aſtringents; and by varying the ſtrength of mordants, an infinity of ſhades may be produced. In this caſe, it is leſs a combination or ſolution of principles than the ſimple mixture or juxta-poſition of the colouring bodies on the ſtuff. By means of a boiling heat, we may combine, in a more intimate manner, the oxyd of iron with the aſtringent principle; and then it is brought to the ſtate of black oxyd, as has been obſerved by Berthollet. It is poſſible alſo to embrown theſe colours, and to give them a variety of tints, from the bright grey to the deep black, by merely paſſing the cottons impregnated with the aſtringent principle thro' a ſolution of iron. The oxyd is then precipitated itſelf by the principle which is fixed on the ſtuff.

An obſervation, which may become of the utmoſt value for the art of dyeing, is, that the moſt uſual aſtringent vegetables all furniſh a yellow colour, which has not much brilliancy, but which has ſufficient fixity to be employed with advantage. This yellow colour is brightened in the ſeries of vegetables, in proportion as the aſtringent principle is diminiſhed, and the vivacity of the colour is augmented in the ſame proportion. It is difficult, then, to obtain yellow colours which are at the ſame time durable and brilliant. Theſe two valuable qualities are to each other in an inverſe ratio; but it is poſſible to unite the colouring principles in ſuch a manner as to combine ſplendour with fixity. Green oak bark unites perfectly with yellow weed, and ſumach with green citron. It is by this mixture that we may be able to combine with the oxyd of iron vegetable colours, the ſplendour of which is equal to their durability.

Our author concludes his obſervations with cautioning the dyer againſt ſubſtituting ſumach and the bark of the alder tree or oak for gall when dyeing cotton red. "I can ſafely aſſert (ſays he), that it is impoſſible to employ theſe as ſubſtitutes, in whatever doſes they may be uſed. The colour is always much paler, poorer, and leſs fixed. I know that the caſe is not the ſame in regard to dyeing wool and ſilk, in which it may be employed with ſucceſs; and in giving an account of this difference, I think the cauſe of it may be found in the nature of the gall-nuts. 1. The acid which they excluſively contain, as Berthollet has proved, facilitates the decompoſition of the ſoap with which the cottons have been impregnated, and the oil then remains fixed in their tiſſue, and in a greater quantity, as well as in a more intimate combination. 2. The gall-nuts, which owe their development to animal bodies, retain a character of animaliſation, which they tranſmit to the vegetable ſtuff, and by theſe means augment its affinities with the colouring principle of the madder; for it is well known of what utility animal ſubſtances are to facilitate this combination. This animaliſation becomes uſeleſs in operating upon woollen or ſilk."

JUAN de Fuca, a celebrated ſtrait on the north-weſt coaſt of America, was ſurveyed by Captain Vancouver in the Diſcovery ſloop of war, with a view to aſcertain whether it leads to any communication between the North Pacific and the North Atlantic Oceans. As they advanced within the opening of the ſtrait, their progreſs was greatly retarded by the number of inlets into which the entrance branched in every direction; and moſt of theſe were examined by the boats, which were frequently abſent from the ſhips on this ſervice for ſeveral days together. In the midſt of their labours, they were ſurpriſed by the ſight of two Spaniſh veſſels of war, employed, like themſelves, in ſurveying this inlet, the examination of which had been begun by them in the preceding year. Meaſures of mutual aſſiſtance were concerted between the captains of the two nations for the proſecution of the ſurvey, in which each agreed to communicate to the other their diſcoveries. Not one of the many arms of the inlet, nor of the channels which they explored in this broken part of the coaſt, was found to extend more than 100 miles to the eaſtward of the entrance into the ſtrait. After having ſurveyed the ſouthern coaſt, on which ſide a termination was diſcovered to every opening, by following the continued line of the ſhore, they were led to the northward, and afterward towards the north-weſt, till they came into the open ſea through a different channel from the ſtrait of Juan de Fuca, by which they had commenced this inland navigation.

Thus it appeared, that the land forming the north ſide of that ſtrait is part of an iſland, or of an archipelago, extending nearly 100 leagues in length from S. E. to N. W.; and on the ſide of this land moſt diſtant from the continent is ſituated Nootka Sound. The moſt peculiar circumſtance of this navigation is the extreme depth of water, when contraſted with the narrowneſs of the channels. The veſſels were ſometimes drifted about by the currents during the whole of a night, cloſe to the rocks, without knowing how to help themſelves, on account of the darkneſs, and the depth being much too great to afford them anchorage.

In the courſe of this ſurvey, the voyagers had frequent communications with the natives, whom they met ſometimes in canoes and ſometimes at their villages. In their tranſactions with Europeans, they are deſcribed as "well verſed in the principles of trade, which they carried on in a very fair and honourable manner." In other reſpects they were leſs honeſt. At one village 200 ſea otter ſkins were purchaſed of them by the crews of the veſſels in the courſe of a day; and they had many more to ſell in the ſame place, as alſo ſkins of bears, deer, and other animals. One party of Indians whom they met had the ſkin of a young lioneſs; and theſe ſpoke a language different from that uſed in Nootka Sound. Veniſon was ſometimes brought for ſale; and a piece of copper, not more than a foot ſquare, purchaſed one whole deer and part of another. Among other articles of traffic, two children, ſix or ſeven years of age, were offered for ſale. The commodities moſt prized by the natives were fire-arms, copper, and great coats. Beads and trinkets they would only receive as preſents, and not as articles of exchange. Many of them were poſſeſſed of fire-arms. In one part it is related, that after a chief had received ſome preſents, "he, with moſt of his companions, returned to the ſhore; and, on landing, fired ſeveral muſkets, to ſhew, in all probability, with what dexterity they could uſe theſe weapons, to which they ſeemed as familiarized as if they had been accuſtomed to fire-arms from their earlieſt infancy."

The dreſſes of theſe people, beſides ſkins, are a kind of woollen garments; the materials compoſing which are explained in the following extract:

"The dogs belonging to this tribe of Indians were numerous, and much reſembled thoſe of Pomerania, though, in general, ſomewhat larger. They were all ſhorn as cloſe to the ſkin as ſheep are in England; and ſo compact were their fleeces, that large portions could be lifted up by a corner without cauſing any ſeparation. They were compoſed of a mixture of a coarſe kind of wool, with very fine long hair, capable of being ſpun into yarn. This gave Captain Vancouver reaſon to believe, that their woollen clothing might in part be compoſed of this material mixed with a finer kind of wool from ſome other animal, as their garments were all too fine to be manufactured from the coarſe coating of the dog alone."

Of other animals alive, deer only were ſeen in any abundance by our people.

The number of inhabitants computed to be in the largeſt of the villages or towns that were diſcovered, did not exceed 600. Captain Vancouver conjectured the ſmall-pox to be a diſeaſe common and very fatal among them Many were much marked; and moſt of theſe had loſt their right eye. Their method of diſpoſing of their dead is very ſingular.

"Baſkets were found ſuſpended on high trees, each containing the ſkeleton of a young child; in ſome of which were alſo ſmall ſquare boxes filled with a kind of white paſte, reſembling (ſays our author) ſuch as I had ſeen the natives eat, ſuppoſed to be made of the ſaranne root; ſome of theſe boxes were quite full, others were nearly empty, eaten probably by the mice, ſquirrels, or birds. On the next low point ſouth of our encampment, where the gunners were airing the powder, they met with ſeveral holes in which human bodies were interred, ſlightly covered over, and in different ſtates of decay, ſome appearing to have been very recently depoſited. About half a mile to the northward of our tents, where the land is nearly level with high water mark, a few paces within the ſkirting of the wood, a canoe was found ſuſpended between two trees, in which were three human ſkeletons.

"On each point of the harbour, which, in honour of a particular friend, I called *Penn's Cove*, was a deſerted village; in one of which were found ſeveral ſepulchres, formed exactly like a centry box. Some of them were open, and contained the ſkeletons of many young children tied up in baſkets: the ſmaller bones of adults were likewiſe noticed, but not one of the limb bones could here be found; which gave riſe to an opinion, that theſe, by the living inhabitants of the neighbourhood, were appropriated to uſeful purpoſes; ſuch as pointing their arrows, ſpears, or other weapons."

However honourably theſe people have been repreſented in their conduct as traders, it appeared on ſeveral occaſions that it was unſafe to depend on their goodwill alone: and ſome inſtances occurred, of their making every preparation for an attack, from which they deſiſted only on being doubtful of the event; yet immediately on relinquiſhing their purpoſe, they would come with the greateſt confidence to trade, appearing perfectly regardleſs of what had before been in agitation. The boats, as already noticed, were frequently at a great diſtance from the ſhips; and on ſuch occaſions, when large parties of Indians have firſt ſeen them, they generally held long conferences among themſelves before they approached the boats; probably for the purpoſe of determining the mode of conduct which they judged it moſt prudent to obſerve. Captain Vancouver places the entrance of the ſtrait of Juan de Fuca in 48° 20′ N. Lat. and 124° W. Long.

JUGGLERS are a kind of people whoſe profeſſion has not been often deemed either reſpectable or uſeful. Profeſſor Beckmann, however, has undertaken their defence; and in a long and learned chapter in the third volume of his *Hiſtory of Inventions*, pleads the cauſe of the practiſers of legerdemain; rope-dancers; perſons who place their bodies in poſitions apparently dangerous; and of thoſe who exhibit feats of uncommon ſtrength. All theſe men he claſſes under the general denomination of *Jugglers;* and taking it for granted (ſurely upon no good grounds) that every uſeful employment is full, he contends, that there would not be room on the earth for all its preſent inhabitants did not ſome of them practiſe the arts of *Juggling*.

"Theſe arts (ſays he) are indeed not unprofitable, for they afford a comfortable ſubſiſtence to thoſe who practiſe them; but their gain is acquired by too little labour to be hoarded up; and, in general, theſe roving people ſpend on the ſpot the fruits of their ingenuity; which is an additional reaſon why their ſtay in a place ſhould be encouraged. But farther, it often happens, that what ignorant perſons firſt employ, merely as a ſhow, for amuſement or deception, is afterwards ennobled by being applied to a more important purpoſe. The machine with which a Savoyard, by means of ſhadows, amuſed children and the populace, was by Liberkühn converted into a ſolar microſcope; and, to give one example more, the art of making ice in ſummer, or in a heated oven, enables gueſts, much to the credit of their hoſteſs, to cool the moſt expenſive diſhes. The Indian diſcovers precious ſtones, and the European, by poliſhing, gives them a luſtre.

"But, if the arts of juggling ſerved no other end than to amuſe the moſt ignorant of our citizens, it is proper that they ſhould be encouraged for the ſake of thoſe who cannot enjoy the more expenſive deceptions of an opera. They anſwer other purpoſes, however, than that of merely amuſing: they convey inſtruction in the moſt acceptable manner, and ſerve as an agreeable antidote to ſuperſtition, and to that popular belief in miracles, exorciſm, conjuration, ſorcery, and witchcraft, from which our anceſtors ſuffered ſo ſeverely."

Surely this reaſoning, as well as the cauſe in which it is brought forward, is unworthy of the learning of Beckmann. It is indeed true, that jugglers ſpend their money freely, and that their arts afford them the means of ſubſiſtence; but it is very ſeldom, as our author muſt know, that they ſubſiſt either comfortably or innocently. Is it innocent to entice the ignorant and labouring poor, by uſeleſs deceptions, to part with their hard-earned pittance to idle vagabonds? or is the life of thoſe vagabonds comfortable, when it is paſſed amid ſcenes of the moſt grovelling diſſipation? Jugglers ſpend indeed their money, for the moſt part, on the ſpot where it is gained; but they ſpend it in drunkenneſs, and other ſeducing vices, which corrupt their own morals and the morals of all with whom they aſſociate; and therefore their ſtay in a place ſhould certainly *not* be encouraged. Could it be proved that the ſolar microſcope would never have been invented, had not a Savoyard juggler contrived a ſimilar machine to amuſe children and the rabble, ſome ſtreſs might be laid on the ſervice which ſuch wretches have rendered to ſcience: but where is the man that will ſuppoſe the philoſophy of Bacon and Newton to reſt upon the arts of juggling? or who conſiders the refinements of ſcience as of equal value with the morals of the people? There is, at the moment in which this article is drawing up, a fellow exhibiting, before the windows of the writer's chamber, the moſt indecent ſcenes by means of puppets, and keeping the mob in a conſtant roar. Is he innocently employed? or will any good man ſay that there is not room for him in the armies which on the Continent are fighting in the cauſe of God and humanity?

Our author endeavours to ſtrengthen his reaſoning by proving, which he does very completely, the antiquity of juggling. “The deception (ſays he) of breathing out flames, which at preſent excites, in a particular manner, the aſtoniſhment of the ignorant, is very ancient. When the ſlaves in Sicily, about a century and a half before our æra, made a formidable inſurrection, and avenged themſelves in a cruel manner for the ſeverities which they had ſuffered, there was amongſt them a Syrian named Eunus, a man of great craft and courage, who, having paſſed through many ſcenes of life, had become acquainted with a variety of arts. He pretended to have immediate communication with the gods; was the oracle and leader of his fellow ſlaves; and, as is uſual on ſuch occaſions, confirmed his divine miſſion by miracles. When, heated by enthuſiaſm, he was deſirous of inſpiring his followers with courage, he breathed flames or ſparks among them from his mouth while he was addreſſing them. We are told by hiſtorians, that for this purpoſe he pierced a nut-ſhell at both ends, and, having filled it with ſome burning ſubſtance, put it into his mouth and breathed through it.

“This deception, at preſent, is performed much better. The juggler rolls together ſome flax or hemp, ſo as to form a ball about the ſize of a walnut; ſets it on fire; and ſuffers it to burn till it is nearly conſumed; he then rolls round it, while burning, ſome more flax; and by theſe means the fire may be retained in it for a long time. When he wiſhes to exhibit, he ſlips the ball unperceived into his mouth and breathes through it; which again revives the fire, ſo that a number of weak ſparks proceed from it; and the performer ſuſtains no hurt, provided he inſpire the air not through the mouth but the noſtrils.

“For deceptions with fire the ancients employed alſo naphtha, a liquid mineral oil, which kindles when it only approaches a flame. (See NAPHTHA, *Encycl.*) Galen informs us, that a perſon excited great aſtoniſhment by extinguiſhing a candle and again lighting it, without any other proceſs than holding it immediately againſt a wall or a ſtone. The whole ſecret of this conſiſted in having previouſly rubbed over the wall or ſtone with ſulphur. But as the author, a few lines before, ſpeaks of a mixture of ſulphur and naphtha, we have reaſon to think that he alludes to the ſame here. Plutarch relates how Alexander the Great was aſtoniſhed and delighted with the ſecret effects of naphtha, which were exhibited to him at Ecbatana. The ſame author, as well as Pliny, Galen, and others, has already remarked, that the ſubſtance with which Medea deſtroyed Creuſa, the daughter of Creon, was nothing elſe than this fine oil. She ſent to the unfortunate princeſs a dreſs beſmeared with it, which burſt into flames as ſoon as ſhe approached the fire of the altar. The blood of Neſſus, in which the dreſs of Hercules, which took fire likewiſe, had been dipped, was undoubtedly naphtha alſo; and this oil muſt have been always employed when offerings caught fire in an imperceptible manner.

“In modern times, perſons who could walk over burning coals or red-hot iron, or who could hold red-hot iron in their hands, have often excited wonder. But laying aſide the deception ſometimes practiſed on the ſpectators, the whole of this ſecret conſiſts in rendering the ſkin of the ſoles of the feet and hands ſo callous and inſenſible, that the nerves under them are ſecured from all hurt, in the ſame manner as by ſhoes and gloves. Such calloſity will be produced if the ſkin is continually compreſſed, ſinged, pricked, or injured in any other manner. Thus do the fingers of the induſtrious ſempſtreſs become horny by being frequently pricked; and the caſe is the ſame with the hands of fire-workers, and the feet of thoſe who walk bare footed over ſcorching ſand.

“In the month of September 1765, when I viſited (ſays our author) the copper-works at Aweſtad, one of the workmen, for a little drink-money, took ſome of the melted copper in his hand, and after ſhewing it to us, threw it againſt a wall. He then ſqueezed the fingers of his horny hand cloſe to each other; put it a few minutes under his arm-pit, to make it ſweat, as he ſaid; and, taking it again out, drew it over a ladle filled with melted copper, ſome of which he ſkimmed off, and moved his hand backwards and forwards, very quickly, by way of oſtentation. While I was viewing this performance, I remarked a ſmell like that of ſinged horn or leather, though his hand was not burnt. It is highly probable, that people who hold in their hands red hot iron, or who walk upon it, as I ſaw done at Amſterdam, but at a diſtance, make their ſkin callous before, in the like manner. This may be accompliſhed by frequently moiſtening it with ſpirit of vitriol; according to ſome the juice of certain plants will produce the ſame effect; and we are aſſured by others, that the ſkin muſt be very frequently rubbed, for a long time, with oil, by which means, indeed, leather alſo will become horny*.”

Our author then proves, in a very learned manner, that all theſe tricks were of high antiquity; that the Hirpi, who lived near Rome, jumped through burning coals; that women were accuſtomed to walk over burning coals at Caſtabala in Cappadocia, near the temple dedicated to Diana; that the exhibition of balls and cups (ſee LEGERDEMAIN, *Encycl.*) is often mentioned in the works of the ancients; that in the third century, one Firmus or Firmius, who endeavoured to make himſelf emperor in Egypt, ſuffered a ſmith to forge iron on an anvil placed on his breaſt; that rope-dancers with balancing poles are mentioned by Petronius and others; and that the various feats of horſemanſhip exhibited in our circuſes paſſed, in the thirteenth century, from Egypt to the Byzantine court, and thence over all Europe.

JUNGLE, in Bengal, waſte land, or land covered with wood and brambles.

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* *Haller, Elementa Phyſiolog.*

K.

Kaarta.

KAARTA, a kingdom in Africa, through which Mr Park paſſed in his route from the Gambia to the Niger. He deſcribes the country as conſiſting either of ſandy plains or rocky hills; but, from his account, the level part ſeems to be the moſt extenſive. The natives are negroes, of whom many, though converted to the Mahomedan faith, or rather to the ceremonial part of the Mahomedan religion, retain all their ancient ſuperſtitions, and even drink ſtrong liquors. They are called Johers or Jowers, and in Kaarta form a very numerous and powerful tribe. One of theſe men undertook to conduct our author to Kemmoo, the capital of the kingdom, and alarmed him not a little by his ſuperſtitious ceremonies.

“ We had no ſooner (ſays Mr Park) got into a dark and lonely part of the firſt wood, than he made a ſign for us to ſtop, and taking hold of a hollow piece of bamboo, that hung as an amulet round his neck, whiſtled very loud, three times. I confeſs I was ſomewhat ſtartled, thinking it was a ſignal for ſome of his companions to come and attack us; but he aſſured me that it was done merely with a view to aſcertain what ſucceſs we were likely to meet with on our preſent journey. He then diſmounted, laid his ſpear acroſs the road, and having ſaid a number of ſhort prayers, concluded with three loud whiſtles; after which he liſtened for ſome time, as if in expectation of an anſwer, and receiving none, told us we might proceed without fear, for there was no danger.”

White men were ſtrangers in the kingdom of Kaarta; and the appearance of our author had on ſome of the natives the effect which ignorant people, in this country, attribute to ghoſts. “ I had wandered (ſays he) a little from my people, and being uncertain whether they were before or behind me, I haſtened to a riſing ground to look about me. As I was proceeding towards this eminence, two negro horſemen, armed with muſkets, came galloping from among the buſhes: on ſeeing them I made a full ſtop; the horſemen did the ſame, and all three of us ſeemed equally ſurpriſed and confounded at this interview. As I approached them their fears increaſed, and one of them, after caſting upon me a look of horror, rode off at full ſpeed; the other, in a panic of fear, put his hand over his eyes, and continued muttering prayers until his horſe, ſeemingly without the rider's knowledge, conveyed him ſlowly after his companion. About a mile to the weſtward, they fell in with my attendants, to whom they related a frightful ſtory: it ſeems their fears had dreſſed me in the flowing robes of a tremendous ſpirit; and one of them affirmed, that when I made my appearance, a cold blaſt of wind came pouring down upon him from the ſky like ſo much cold water.”

At Kemmoo our traveller was graciouſly received by the king; who honeſtly told him, however, that he could not protect him, being then engaged in war with the king of BAMBARRA (ſee SEGO in this *Supplement*); but he gave him a guard to JARRA, the frontier town of the neighbouring kingdom of Ludamar. The origin and iſſue of this war between Kaarta and Bambarra, of which Mr Park gives a full account, ſhews the folly of attempting to liberate the negroes from ſlavery till civilization and Chriſtianity be introduced into Africa. Major Rennel places Kemmoo, the capital of Kaarta, in 14° 15′ N. Lat. and 7° 20′ W. Lon.

Kabobiquas.

KABOBIQUAS, a nation in ſouth Africa, who had never ſeen a white man till 1785, that they were viſited by M. Vaillant. Intimation had been given of his approach by ſome of the tribes through whoſe country he had previouſly paſſed; and every thing that had been ſaid of his colour, his fuſees, and his equipage, bore the character of the moſt enthuſiaſtic exaggeration. The curioſity of the people was wound up to the higheſt pitch; and as ſoon as they ſaw his company at a diſtance, the whole horde quitted the kraal, and ran with eagerneſs to meet him. Not being able to believe their eyes in regard to what they ſaw, they endeavoured to obtain more ſatisfaction by touching him. They felt his hair, hands, and almoſt every part of his body. His beard, above all, aſtoniſhed them to an inconceivable degree. More than thirty perſons came in ſucceſſion, and half unbuttoned his clothes. They all imagined him to be a hairy animal; and ſuppoſed, without doubt, that his body was covered with hair as long as that on his chin; but finding this not to be the caſe, they were aſtoniſhed, and confeſſed, with the openneſs of ſavages, that they had never ſeen the like in any man of their country. The little children, terrified at his appearance, hid themſelves behind their mothers. When he attempted to lay hold of any of them, in order to careſs them, they ſent forth loud cries, as a child would do in Europe who ſhould ſee a negro for the firſt time.

The grown up people, however, were ſoon reconciled to his appearance, and even the children were bribed by ſmall bits of ſugar candy. The chief of the horde ſhowed him every mark of attachment. He was a man advanced in life, and of a majeſtic figure. He wore a long mantle, which hung from his ſhoulders to the ground, and which, formed of four jackal ſkins joined together, was bordered at the ſides with that of a hyæna. His left hand wanted two joints of the little finger, which, he ſaid, were amputated in his infancy to cure him of a ſevere illneſs.

This cuſtom of ſavages, who, to relieve a man from pain, add new ſufferings to his evils, affords a vaſt field for reflection. Mr Paterſon, another African traveller, tells us, that he obſerved inſtances of the ſame practice among a horde at the mouth of Orange-river; which is not improbable. However abſurd a cuſtom may be, ſavage tribes, when they are neighbours, may borrow it from each other; but that it ſhould be common among the iſlanders of the South Sea, who, ſince their country was firſt inhabited, had never ſeen ſtrangers before Cook and Bougainville, is truly aſtoniſhing. Our author was very deſirous of interrogating minutely the people of the horde on this ſubject. He wiſhed alſo to propoſe ſome queſtions to them reſpecting other cuſtoms which appeared ſingular; but difficulties increaſed the more he advanced into the country. The Kabobiquas ſpoke a particular language; and this dialect, though accompanied with the clapping noiſe of the Hottentots, was underſtood only by the Koraquas, who, on account of their vicinity, kept up ſome intercourſe with them. The caſe was the ſame with the language of the Koraquas, in regard to their neighbours the Nimiquas; and nothing reached our author's ear till it had paſſed through four different mouths. The conſequence was, that when he aſked any thing, the anſwer had frequently no relation to the queſtion; and for this inconveniency no remedy could be found.

The ſame deſire for trinkets to ornament their dreſs prevailed among the Kabobiquas as among the other hordes which Vaillant had viſited; and in one day he purchaſed twenty oxen for things of that kind of no value. The chief, however, had ſet his affections on a razor; and juſt when our author and he were treating about it, a ſhot was fired near them, which was inſtantly followed by the moſt frightful cries. "Ruſhing inſtantly from my tent (ſays M. Vaillant) to enquire what was the cauſe of this noiſe, I ſaw a Kabobiqua flying as faſt as he could from one of my hunters, while, at the diſtance of a hundred paces farther, three men were making the moſt lamentable clamour, and near them was a young girl lying on the ground. I made a ſignal to my hunter to approach me; but the report of the ſhot, and the howling of the three men, had already ſpread alarm throughout the horde. Some cried out treachery; others ran to their arms; and I now imagined that I was about to be maſſacred, with my whole company, and that I ſhould be obliged to arm them in my defence. My ſituation was the more critical, as neither I, nor any perſon in the kraal, knew what was the cauſe of this confuſion; and if I had known, how could I have explained it?

"Under this embarraſſment, I took the chief by the hand, and advanced with him towards the horde. Fear was painted in his countenance; tears began to drop from his eyes; and he ſpoke to me with great vivacity. He imagined, no doubt, that he was betrayed. He complained to me, and accuſed my people of perfidy; yet he readily followed me.

"As I was without arms, and preſented myſelf with the chief, I was received with confidence, and my appearance ſeemed, in ſome meaſure, to calm their perturbation. My people, who had ſeen me direct my courſe towards the kraal, haſtened thither after me, to protect me; and their number overawed the multitude. At length the whole myſtery was cleared up, and we learned what had occaſioned the tumult.

"A Kabobiqua having met one of my hunters, who was returning with his fuſee, wiſhed to examine it, and begged him to ſhew it to him. In handling it, however, he accidentally touched the trigger; it inſtantly went off; and the ſavage, frightened by the unexpected exploſion, threw down the fuſee, and ran away as faſt as he could.

"At that time, three men of the horde and a young girl happened unluckily to be ſtanding, at the diſtance of a hundred paces, in the direction of the piece. The latter received a ſingle grain of ſhot in the cheek; and the others a few grains in the legs and thighs. The author of the misfortune confirmed this explanation; tranquillity was ſoon reſtored; the ſavages depoſited their arms; and I was ſurrounded only by friends as before.

"Nothing remained but to enquire into the ſtate of the wounded, and to give them every aſſiſtance in my power. Without loſs of time, therefore, I repaired, ſtill accompanied by the chief, to the place where they were. By the way we met the young girl, who was returning from the kraal, bathed in tears. The cauſe of her uneaſineſs was a grain of lead, which had, however, penetrated ſo little, that I forced it out by only preſſing the part with my fingers. With regard to the three men, they lay rolling on the ground, howling in a moſt frightful manner, and exhibiting every ſymptom of deſpair.

"I was aſtoniſhed at their conſternation, and could not conceive how men inured to ſufferings ſhould be ſo much affected by a few ſmall punctures, the pain of which could have ſcarcely drawn tears from an infant. They at length told me the cauſe of their wailings. Theſe ſavages, accuſtomed to poiſon their arrows, imagined that I had in like manner poiſoned the lead with which they were wounded. They had, therefore, given themſelves up as loſt, and expected in a few moments to expire."

It was with great difficulty that our author could convince them that they had nothing to fear. He ſhewed them in the fleſh of his own leg a dozen of ſhots of lead; but they were not ſatisfied till one of the moſt intelligent of his Hottentots, taking from his ſhot bag a few grains of lead, and ſhewing them to the three men, immediately ſwallowed them. This concluſive argument produced the deſired effect. The cries of the wounded men inſtantly ceaſed; ſerenity again appeared in their faces; and their wounds were no more mentioned.

The Kabobiquas have neither the flat noſe nor plump cheeks of the Hottentots. Their ſkin alſo has not that baſtard colour, which, being neither black nor white, renders them odious to both races; nor do they beſmear their bodies with thoſe diſguſting fat ſubſtances, on account of which one cannot approach them without being bedaubed with their filth, or acquiring an offenſive ſmell. In ſtature they are as tall as the Caffres, and their colour is equally black. Their hair, which is exceedingly ſhort, and much curled, is ornamented with ſmall copper buttons, arranged with great art and ſymmetry. Inſtead of that apron made of a jackal's ſkin, employed by the Hottentot to cover what modeſty bids him conceal, the Kabobiquas uſe a round piece of leather, the edge of which is ornamented with a ſmall indented circle of copper, and which is divided into different compartments by rows of glaſs beads of various colours, all proceeding from the centre, and diverging towards the circumference, like the rays in our images of the ſun.

This kind of veil is made faſt to the groin by means of a girdle; but as it is only four inches in diameter, as it is deranged by the ſmalleſt movement, and as they give themſelves little uneaſineſs reſpecting ſuch accidents, it is very ill ſuited to the purpoſe for which it is applied. During the great heats, this ſmall and almoſt uſeleſs apron is the only covering on their bodies. Its being ſo readily diſplaced, enabled our author to aſcertain that they do not practice circumciſion; but it ſeemed to ſhow alſo, that, in regard to modeſty, their ideas are very different from ours.

Though they go thus almoſt entirely naked, their manners, inſtead of being licentious, are remarkably chaſte.

Kabobiquas.

chaſte. No females can be more prudent or more reſerved than their women; and whether from refinement of coquetry, or the effect of prudence, they do not tattoo their faces like their huſbands and fathers. They do not even follow their example in ornamenting their hair with copper buttons; and they always go barelegged, though moſt of them wear ſandals.

Their dreſs conſiſts of an apron that reaches only half down the thigh; a kroſs which, paſſing under the arm-pits, is tied on the breaſt; and a long mantle like that of the men. The mantle is made of ſkins not deprived of the hair; and the kroſs of tanned leather, prepared like that uſed for gloves in Europe.

With regard to glaſs beads, they wear them as bracelets. They form them alſo into necklaces, which deſcend in different rows to the pit of the ſtomach; and they ſuſpend from their girdles ſeveral ſtrings of them, which fall down their thighs below the apron.

Theſe ornaments being very durable, the habit of ſeeing them renders the women almoſt indifferent to the pleaſure of poſſeſſing them. Thoſe they procured from our author afforded at firſt great ſatisfaction, on account of their novelty. But when he ſhewed them ſciſſars and needles, they gave the preference to theſe articles; and this choice does honour to the good ſenſe of the Kabobiqua ladies. Like their chief, they ſet a higher value on utility than ornament.

Before our author's arrival among them, the Kabobiquas were acquainted with the uſe of tobacco through the means of ſome of the tribes more contiguous to the Cape. It was, however, a luxury which they could ſeldom enjoy; and ſo indifferent were they about it, that if it were not brought to them, they would not go a ſtep to procure it. This indifference, about an article which is eagerly ſought for by all the tribes of Hottentots, ſeemed to ſhew that there are traits in the character of the Kabobiquas which diſtinguiſh them from their ſouthern neighbours. The caſe was the ſame as to ſtrong liquors, on which they ſet no great value; and though there were among them ſome few individuals diſpoſed to reliſh them, the greater number abſolutely refuſed them.

“If the contents of my flaſks (ſays Vaillant) gave them little ſatisfaction, they were, however, much captivated with the flaſks themſelves. Theſe tranſparent bottles excited their admiration in the higheſt degree. They called them *ſolid water*; for, notwithſtanding the heat of the climate, theſe ſavages had ſeen ice on the ſummits of the mountains by which they are ſurrounded; and they entertained no doubt that the glaſs of my flaſks was water, which I had rendered ſolid by magic, and which I prevented their fires from melting. As it was impoſſible for me to explain this matter, I did not attempt to undeceive them: and beſides, with what advantage would it have been attended? I ſuffered them, therefore, to continue in their error, and contented myſelf with conferring on them an obligation, by giving them all the empty bottles for which I had no uſe.

“On their part, they vied with each other in ſhewing their generoſity towards me; and I muſt indeed allow, that I never ſaw a nation ſo diſintereſted. Every night they brought to my camp a conſiderable quantity of milk; and they never came to ſpend the evening with my people, without bringing ſome ſheep to regale them. I have ſeen many of them give away gratuitouſly, and without receiving any thing in return, part of their herds and their flocks; and, when I departed, there were many perſons in my caravan who poſſeſſed both ſheep and oxen, which they had received as a pure gift.”

Kabobiquas.

With this benevolent diſpoſition, the Kabobiquas have alſo a martial character. Their weapons are poiſoned arrows, and a lance with a long iron point, but different from the aſſagay of the Hottentots. In battle, their defenſive armour conſiſts of two bucklers; the one of a ſize ſufficient to cover the whole body of the combatant; the other much ſmaller. They are both made of ſkins exceedingly thick, and proof againſt arrows.

The courage which the Kabobiquas diſplay in combat is particularly exerciſed in their hunting excurſions, and, above all, againſt carnivorous animals. Intrepid, however, as it may be to attack the elephant and the rhinoceros, theſe ſpecies of animals are not objects of their vengeance; becauſe, living upon graſs and herbs, they have nothing to apprehend from them, either for themſelves or their cattle. But the tiger, lion, hyæna, and panther, being enemies of a different kind, they declare againſt them implacable war, and purſue them without remiſſion.

Of the ſpoils of theſe deſtructive animals they form their bucklers, girdles, ſandals, kroſſes, mantles, &c. They conſider it as a mark of honour to wear them; and they ſet a much higher value upon them than upon the ſkin of the rhinoceros or of the elephant. If they ſometimes hunt the latter, it is only as objects of food; and they employ to catch them thoſe concealed pits, which are the uſual ſnares of the Hottentots: but this method, which requires both patience and labour, is very little ſuited to a people ſo brave and enterpriſing as the Kabobiquas.

As they poſſeſs ſo bold and reſolute a character, one might be induced to believe that they are ferocious and intractable. Among all the African nations, however, which our author viſited, he never knew one that ſo much practiſed obedience and ſubordination.

The chief here is not, as in other tribes, a principal among his equals; he is a ſovereign in the midſt of his ſubjects, a maſter ſurrounded by his ſlaves. A word, a geſture, or a look, is ſufficient to procure him obedience. Whatever be his orders, they are never contradicted; and the caſe is the ſame in every particular family. What the chief is to the horde, the father is to his children. His commands are abſolute; and he exerciſes regal power at home, while he obeys elſewhere.

Though the tribe was very numerous, the wiſdom with which it was ruled, and the good order that prevailed, announced, in the man by whom it was governed, an intelligence ſuperior to that of all the ſavages our author had before ſeen; for he had not then viſited the Houzouanas. The habitation of this chief was ſuited to his ſupreme dignity. It was, indeed, a hut only, like thoſe of his ſubjects, and, like them, covered with the ſkins of animals; but it was much larger, as well as more elevated; and around it were ſix others, occupied by his family, and deſtined for them alone.

The natural dryneſs of the country inhabited by the Kabobiquas obliges them to dig wells, for their own uſe as well as for their cattle; but as the ſame cauſe often dries up theſe wells, they are then forced to remove, and to ſeek elſewhere a ſoil more abundant in ſprings; for Fiſh-River, though conſiderable in the rainy ſeaſon, is often, during the great heats, entirely deſtitute of water.

The long journeys which theſe too frequent emigrations compel them to undertake, and the intercourſe which they thence have with other nations, muſt neceſſarily inſpire them with ideas unknown to the ſettled tribes; and it would not be unnatural to ſuppoſe, that to this extenſion of ideas are they indebted for that ſuperiority of intelligence which elevates them above their neighbours.

Of the religion of the Kabobiquas, our author talks very inconſiſtently, and like a true philoſopher of the French ſchool. "Of all the African nations (ſays he), they are the only people among whom I found any idea, however confuſed a one, of the exiſtence of a Deity. I do not know whether it be from their own reflection, or the communications of other tribes, that they have acquired this ſublime knowledge, which would alone bring them near to a level with poliſhed nations; but they believe, as far as I have been able to learn from my people, that beyond the ſtars there exiſts a Supreme Being, who made and who governs all things. I muſt however obſerve, that on this ſubject their ideas are vague, barren, and unproductive. They have no conception of the future exiſtence of the ſoul, or of rewards and puniſhments in another life; in ſhort, they have neither worſhip, ſacrifices, ceremonies, nor prieſts, and are total ſtrangers to what we call religion."

This is impoſſible. A people believing in a Supreme Being, who made and who governs all things, *may* indeed be without *ſacrifices*, *ceremonies*, and *prieſts*; but ſuch a people cannot avoid *wiſhing*, that the Being who governs all things may protect them. Such a wiſh is a prayer; and ſurely he who prays is no ſtranger to religion. M. Vaillant places the country of the Kabobiquas between 23° and 25° S. Lat. and 16° 25′ and 19° 25′ Lon. eaſt from Paris.

KAJAAGA, an African kingdom, called by the French *Gallam*, is bounded on the ſouth-eaſt and ſouth by Bambouk; on the weſt, by Bondou and Foota Torra; and on the north, by the river Senegal. The air and climate (ſays Mr Park) are more pure and ſalubrious than at any of the ſettlements towards the coaſt; the face of the country is every where interſperſed with a pleaſing variety of hills and valleys; and the windings of the Senegal river, which deſcends from the rocky hills of the interior, make the ſcenery on its banks very pictureſque and beautiful.

The inhabitants are called Serawoollies, or (as the French write it) *Seracolets*. Their complexion is a jet black: they are not to be diſtinguiſhed in this reſpect from the Jaloffs.

The government is monarchical; and the regal authority, from what I experienced of it, ſeems to be ſufficiently formidable. The people themſelves, however, complain of no oppreſſion; and ſeemed all very anxious to ſupport the king in a conteſt he was going to enter into with the ſovereign of Kaſſon. The Serawoollies are habitually a trading people; they formerly carried on a great commerce with the French in gold and ſlaves, and ſtill maintain ſome traffic in ſlaves with the Britiſh factories on the Gambia. They are reckoned tolerably fair and juſt in their dealings, but are indefatigable in their exertions to acquire wealth, and they derive conſiderable profits by the ſale of ſalt and cotton cloth in diſtant countries. When a Serawoolli merchant returns home from a trading expedition, the neighbours immediately aſſemble to congratulate him upon his arrival. On theſe occaſions the traveller diſplays his wealth and liberality, by making a few preſents to his friends; but if he has been unſucceſsful, his levee is ſoon over; and every one looks upon him as a man of no underſtanding, who could perform a long journey, and (as they expreſs it) *bring back nothing but the hair upon his head.*

Their language abounds much in gutturals, and is not ſo harmonious as that ſpoken by the Foulahs: it is, however, well worth acquiring by thoſe who travel through this part of the African continent; it being very generally underſtood in the kingdoms of Kaſſon, Kaarta, Ludamar, and the northern parts of Bambara. In all theſe countries the Serawoollies are the chief traders.

Joag, the frontier town of this kingdom as you enter it from Piſania, may be ſuppoſed, on a groſs computation, to contain two thouſand inhabitants. It is ſurrounded by a high wall, in which are a number of port holes, for muſquetry to fire through in caſe of an attack. Every man's poſſeſſion is likewiſe ſurrounded by a wall; the whole forming ſo many diſtinct citadels; and amongſt a people unacquainted with the uſe of artillery, theſe walls anſwer all the purpoſes of ſtronger fortifications. To the weſtward of the town is a ſmall river, on the banks of which the natives raiſe great plenty of tobacco and onions. Mr Park was in this town plundered of half his effects by order of the king, becauſe forſooth he had neglected to pay the accuſtomed duties before he entered the kingdom; and it required a good deal of addreſs to prevent himſelf and his attendants from being made ſlaves; a ſtate to which the law, it was ſaid, condemned them for the commiſſion of this unintended crime. He was at laſt reſcued from Joag by a nephew of the king of Kaſſon. Joag is placed by Major Rennel in 14° 25′ N. Lat. and 9° 46′ W. Lon.

KAINSI is the name given by the Hottentots to a particular ſpecies of antelope, of which, according to Vaillant, no author has yet given a perfect deſcription. It is called by the Dutch *klip-ſpringer*, on account of the eaſe with which it leaps from rock to rock; and indeed of all the antelopes there is no one equal to it in agility. It is about the ſize of a kid of a year old, and of a yellowiſh grey colour; but its hair has this peculiarity, that, inſtead of being round, pliable, and firm, like that of moſt other quadrupeds, it is flat, harſh, and ſo little adherent to the ſkin, that the ſlighteſt friction makes it fall off. Nothing is more eaſy, therefore, than to deprive this animal of its hair: dead or alive it is the ſame; to rub, or even to touch the animal, is ſufficient Another peculiarity of this ſingular hair is its being extremely fragile; ſo that if you take a tuft of it between your fingers, and twiſt it with the other hand, it will break like the barbs of a feather. This property, however, belongs not excluſively to the hair of the kainſi: for our author ſays he has obſerved it in the hair of other quadrupeds, which in the ſame manner live among the rocks.

This antelope differs from the other ſpecies alſo in the ſhape of the foot, which, inſtead of being pointed like theirs, is rounded at the end; and as it is always accuſtomed, both in leaping and walking, to tread with the point of the hoof, without reſting at all on the heel, it leaves a print diſtinguiſhable from that of any other antelope in Africa. Its fleſh is exquiſitely flavoured, and much ſought after, particularly by the hunters.

The chace of the kainſi is very amuſing. It is true, it is ſcarcely poſſible to hunt it down with dogs, as it ſoon eſcapes them by means of its inconceivable agility, and gets out of their reach on the point of ſome detached rock, where it will remain whole hours ſafe from all purſuit, and ſuſpended, as it were, above the abyſs. But in this ſituation it is excellently placed for the arrow or the ball of the huntſman; who is commonly certain of ſhooting it at pleaſure, though he is not always able to come at it when killed. We ſhall give our author's account of a chace of the kainſi in his own words.

" I was hunting (ſays he) one of theſe animals, when, from the nature of the place, it found itſelf ſo preſſed by my dogs, as to be on the point of being run down and taken. There were apparently no means of eſcape; ſince before it was a vaſt perpendicular rock, by which its courſe was neceſſarily ſtopped. In this wall, however, which appeared to me perfectly ſmooth, was a little ridge, projecting at moſt not above *two inches*, which the kainſi quickly perceived, and, leaping upon it, to my great aſtoniſhment kept itſelf *firm* (A). I imagined, that at any rate it muſt ſoon tumble down; and my dogs, too, ſo fully expected it, that they ran to the bottom of the rock, to be ready to catch it when it fell. To haſten its fall, I endeavoured to haraſs it, and make it loſe its equilibrium; and for this purpoſe I pelted it with ſtones. All at once, as if gueſſing my deſign, it collected its whole ſtrength, bounded over my head, and, falling a few paces from me, darted away with the utmoſt ſpeed. Notwithſtanding the rapidity of its flight, it would have been eaſy for me to have ſhot it; but its leap had ſo ſurpriſed and amuſed me, that I gave it its life." This was generous, if the ſtory be true.

KAMTSCHATKA is inhabited by a people, who are repreſented in the *Encyclopædia* as poſſeſſing almoſt every quality that can diſgrace human nature. We think it incumbent upon us to acknowledge, in this place, that a much more favourable picture of them is drawn by La Perouſe who viſited Kamtſchatka in September 1787. The Ruſſian governor made the commodore and his officers remark the promiſing appearance of ſeveral ſmall fields of potatoes, of which the ſeed had been brought from Irkoutſk a few years before; and purpoſed to adopt mild, though infallible means, of making farmers of the Ruſſians, Coſſacks, and Kamtſchadales. The ſmall-pox in 1769 ſwept away three-fourths of the individuals of the latter nation, which is now reduced to leſs than four thouſand perſons, ſcattered over the whole of the peninſula; and which will ſpeedily diſappear altogether, by means of the continual mixture of the Ruſſians and Kamtſchadales, who frequently intermarry. A mongrel race, more laborious than the Ruſſians, who are only fit for ſoldiers, and much ſtronger, and of a form leſs diſgraceful to the hand of nature, than the Kamtſchadales, will ſpring from theſe marriages, and ſucceed the ancient inhabitants. The natives have already abandoned the *yourts*, in which they uſed to burrow like badgers during the whole of the winter, and where they breathed an air ſo foul as to occaſion a number of diſorders. The moſt opulent among them now build *iſbas*, or wooden houſes, in the manner of the Ruſſians. They are preciſely of the ſame form as the cottages of our peaſants; are divided into three little rooms; and are warmed by a brick ſtove, that keeps up a degree of heat (B) inſupportable to perſons unaccuſtomed to it. The reſt paſs the winter, as well as the ſummer, in *balagans*, which are a kind of wooden pigeon-houſes, covered with thatch, and placed upon the top of poſts twelve or thirteen feet high, to which the women as well as the men climb by means of ladders that afford a footing very inſecure. But theſe latter buildings will ſoon diſappear; for the Kamtſchadales are of an imitative genius, and adopt almoſt all the cuſtoms of their conquerors. Already the women wear their hair, and are almoſt entirely dreſſed, in the manner of the Ruſſians, whoſe language prevails in all the *oſtrogs*; a fortunate circumſtance, ſince each Kamtſchadalian village ſpoke a different jargon, the inhabitants of one hamlet not underſtanding that of the next. It may be ſaid in praiſe of the Ruſſians, that though they have eſtabliſhed a deſpotic government in this rude climate, it is tempered by a mildneſs and equity that render its inconveniences unfelt. They have no reproaches of atrocity to make themſelves, like the Spaniards in Mexico and Peru. The taxes they levy on the Kamtſchadales are ſo light, that they can only be conſidered as a mark of gratitude towards the ſovereign, the produce of half a day's hunting acquitting the impoſts of a year. It is ſurpriſing to ſee in cottages, to all appearance more miſerable than thoſe of the moſt wretched hamlets in our mountainous provinces, a quantity of ſpecies in circulation, which appears the more conſiderable, becauſe it exiſts among ſo ſmall a number of inhabitants. They conſume ſo few commodities of Ruſſia and China, that the balance of trade is entirely in their favour, and that it is abſolutely ceſſary to pay them the difference in rubles. Furs at Kamtſchatka are at a much higher price than at Canton; which proves, that as yet the market of Kiatcha has not felt the advantageous effect of the new channel opened in China.

Our author compares Kamtſchatka, with reſpect to climate and ſoil, to the coaſt of Labrador in the vicinity of the Straits of Belle-Iſle; but the men, like the animals, are there very different. The Kamtſchadales appeared to him the ſame people as thoſe of the bay of Caſtries, upon the coaſt of Tartary. Their mildneſs and their probity are the ſame, and their perſons are very little different. They ought then no more to be compared to the Eſquimaux Indians, than the ſables of Kamtſchatka to the martins of Canada.

The Greek religion has been eſtabliſhed among the Kamtſchadales without perſecution or violence, and with extraordinary facility. The vicar of Paratounka is the ſon of a Kamtſchadale and of a Ruſſian woman. He delivers his prayers and catechiſm with a tone of feeling very

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(A) This we think incredible.

(B) Not leſs than thirty degrees of Reaumur's thermometer.

very much to the taſte of the aborigines, who reward his cares with offerings and alms, but pay no tythes. The canons of the Greek church permitting prieſts to marry, we may conclude that the morals of the country clergymen are ſo much the better. "I believe them, however (ſays Perouſe), to be very ignorant; and do not ſuppoſe, that for a long time to come they will ſtand in need of greater knowledge. The daughter, the wife, and the ſiſter of the vicar, were the beſt dancers of all the women, and appeared to enjoy the beſt ſtate of health. The worthy prieſt knew that we were good Catholics, which procured us an ample aſperſion of holy water; and he alſo made us kiſs the croſs that was carried by his clerk: theſe ceremonies were performed in the midſt of the village. His parſonage-houſe was a tent, and his altar in the open air; but his uſual abode is Paratounka, and he only came to St Peter and St Paul's to pay us a viſit."

The people of Kamtſchatka have inured themſelves to the extremes of heat and cold. It is well known, that their cuſtom in Europe, as well as in Aſia, is to go into vapour baths, come out covered with perſpiration, and immediately roll themſelves in the ſnow. The *oſtrog* of St Peter had two of theſe public baths, into which our author went before the fires were lighted. They conſiſt of a very low room, in the middle of which is an oven conſtructed of ſtones, without cement, and heated like thoſe intended to bake bread. Its arched roof is ſurrounded by ſeats one above another, like an amphitheatre, for thoſe who wiſh to bathe, ſo that the heat is greater or leſs according as the perſon is placed upon a higher or lower bench. Water thrown upon the top of the roof, when heated red-hot by the fire underneath, is converted inſtantly into vapour, and excites the moſt profuſe perſpiration. The Kamtſchadales have borrowed this cuſtom, as well as many others, from their conquerors; and ere long the primitive character that diſtinguiſhed them ſo ſtrongly from the Ruſſians will be entirely effaced.

Our author deſcribes the bay of Avatſcha as the fineſt, the moſt convenient, and the ſafeſt, that is to be met with in any part of the world. The entrance is narrow, and ſhips would be forced to paſs under the guns of the forts that might be eaſily erected. The bottom is mud, and excellent holding ground. Two vaſt harbours, one on the eaſtern ſide, the other on the weſtern, are capable of containing all the ſhips of the French and Engliſh navy. The rivers of Avatſcha and Paratounka fall into this bay, but they are choaked up with ſand-banks, and can only be entered at the time of high water. The village of St Peter and St Paul is ſituated upon a tongue of land, which, like a jetty made by human art, forms behind the village a little port, ſhut in like an amphitheatre, in which three or four veſſels might lie up for the winter. The entrance of this ſort of baſon is more than twenty-five toiſes wide; and nature can afford nothing more ſafe or commodious. On its ſhore the governor propoſed to lay down the plan of a city, which ſome time or other will be the capital of Kamtſchatka, and perhaps the centre of an extenſive trade with China, Japan, the Phillippines, and America. A vaſt pond of freſh water is ſituated northward of the ſite of this projected city; and at only three hundred toiſes diſtance run a number of ſtreamlets, the eaſy union of which would give the ground all the advantages neceſſary to a great eſtabliſhment. Of theſe advantages Mr Kaſloff underſtood the value; "but firſt (ſaid he a thouſand times over) we muſt have bread and hands, and our ſtock of both of them is very ſmall." He had, however, given orders, which announced a ſpeedy union of the other *oſtrogs* to that of St Peter and St Paul, where it was his intention immediately to build a church. By obſervation, St Peter and St Paul was found to be in 53° 1′ N. Lat. and 156° 30′ E. Long. from Paris.

KANEM, is the name given by Edriſi to the kingdom of Bornou in Africa, of which the reader will find ſome account in the *Encyclopædia Britannica*. In ſome particulars, however, that account is incorrect. The kingdom of Bornou or Kanem muſt extend farther eaſt and farther north than it is there ſaid to do; for according to the lateſt and beſt accounts, its capital ſtands in Lat. 24° 32′ Long. 22° 57′. The empire is ſaid to be very extenſive; and if it be true, as we learn from the proceedings of the African Aſſociation, that its ſovereign is more powerful than the Emperor of Morocco, the people cannot be ſuch abſolute brutes, as we have repreſented them in the article referred to; for the ſovereign of brutes would have no power. The truth, however is, that very little is yet known in Europe of Bornou or its inhabitants.

KANT (Immanuel), Royal Profeſſor of Morals and Metaphyſics in the Univerſity of Königſberg, is conſidered by his admirers as the greateſt philoſopher that Germany ever produced. Were we to form an eſtimate of his merits from the different views that have been given in Engliſh of his celebrated ſyſtem, we certainly ſhould not conſider him as entitled to that character; for thoſe views are obſcured by new and uncouth terms, and are altogether wrapt up in a ſtyle which approaches nearer to jargon than to the luminous compoſition of a man who thinks with clearneſs and preciſion. We readily admit, that it is very difficult to tranſlate a novel ſyſtem of metaphyſics from one language into another; for the tranſlator, to perform his taſk properly, muſt be not only a complete maſter of both languages, but alſo a profound metaphyſician; and not one of the tranſlators or abridgers of the works of Kant into our language appears to us poſſeſſed of both theſe qualities. Deſpairing, from our ſcanty knowledge of the German language, of performing ourſelves what ſo many others have failed to perform, we have applied for aſſiſtance to an illuſtrious Frenchman, who has reſided many years in Germany, who is maſter of both languages, who is a profound metaphyſician, and whoſe name, were we at liberty to publiſh it, would reflect luſtre upon our Work. From him we have reaſon to expect a clear and comprehenſive view of the *Critical Philosophy*, as Kant terms his ſyſtem; but ſhould we be diſappointed of our expectation, we ſhall, under that title, lay before our readers a *ſpecimen* of the ſyſtem from the different views of it which have been publiſhed in our own tongue.

KANTUFFA, a ſpecies of thorn peculiar to Abyſſinia, is thus deſcribed by Mr Bruce: The branches ſtand two and two upon the ſtalk; the leaves are diſpoſed two and two likewiſe, without any ſingle one at the point, whereas the branches bearing the leaves part from the ſtalk: at the immediate joining of them are two thick thorns placed perpendicular and parallel alternately; but there are alſo ſingle ones diſtributed in all the interſtices throughout the branch.

The male plant has a one-leaved perianthium, divided into five ſegments, and this falls off with the flower. The flower is compoſed of five petals, in the middle of which riſe ten ſtamina or filaments, the outer row ſhorter than thoſe of the middle, with long ſtigmata, having yellow farina upon them. The flowers grow in a branch, generally between three and four inches long, in a conical diſpoſition, that is, broader at the baſe than the point. The inſide of the leaves are a vivid green, in the outſide much lighter. It grows in form of a buſh, with a multitude of ſmall branches riſing immediately from the ground, and is generally ſeven or eight feet high. Our author ſaw it when in flower only, never when bearing fruit. It has a very ſtrong ſmell, reſembling that of the ſmall ſcented flower called mignionet, ſown in vaſes and boxes in windows, or rooms, where flowers are kept.

Our author repreſents the kantuſſa as ſo very troubleſome, that it renders travelling through ſome places of Abyſſinia almoſt impoſſible. The ſoldier ſcreens himſelf from it by a goat's, a leopard's, or a lion's ſkin thrown over his ſhoulder, of which it has no hold. As his head is bare, he always cuts his hair ſhort before he goes to battle, leſt his enemy ſhould take advantage of it; but the women, wearing their hair long, and the great men, whether in the army or travelling in peace, being always clothed, it never fails to incommode them, whatever ſpecies of raiment they wear. If their cloak is fine muſlin, the leaſt motion againſt it puts it all in rags; but if it is a thick, ſoft cloth, as thoſe are with which men of rank generally travel, it buries its thorns, great and ſmall, ſo deep in it, that the wearer muſt either diſmount and appear naked, which to principal people is a great diſgrace, or elſe much time will be ſpent before he can diſengage himſelf from its thorns. In the time when one is thus employed, it rarely fails to lay hold of you by the hair, and that again brings on another operation, full as laborious, but much more painful, than the other. A proclamation is therefore iſſued, every year immediately before the king commences any march, in theſe words; "Cut down the kantuſſa in the four quarters of the world; for I do not know where I am going." The wild animals, both birds and beaſts, eſpecially the Guinea fowl, know how well it is qualified to protect them. In this ſhelter, the hunter in vain could endeavour to moleſt them, were it not for a hard-haired dog, or terrier of the ſmalleſt ſize, who being defended from the thorns by the roughneſs of his coat, goes into the cover, and brings them and the partridges alive one by one to his maſter.

KASSON, a populous kingdom in North Africa, of which the capital *Kooniakary* is placed by Major Rennel in 14° 33′ N. Lat. and 8° 43′ W. Lon. The king who reigned when Mr Park was in the country was extremely kind to our traveller, though his ſon plundered him unmercifully, like other rapacious chiefs of that ſavage country. From the top of a high hill, at ſome diſtance from the capital, "I had (ſays Mr Park) a moſt enchanting proſpect of the country. The number of towns and villages, and the extenſive cultivation around them, ſurpaſſed every thing I had yet ſeen in Africa. A groſs calculation may be formed of the number of inhabitants in this delightful plain, by conſidering, that the king of Kaſſon can raiſe four thouſand fighting men by the ſound of his war drum."

At Teeſee, a large unwalled town, where our author reſided for ſome days, he had an opportunity of obſerving the cuſtoms of the inhabitants, who conſiſted partly of Pagans and partly of Buſhreens, *i. e.* of negroes converted to Mahomedaniſm. Though theſe people poſſeſs both cattle and corn in abundance, rats, moles, ſquirrels, ſnakes, locuſts, &c. are eaten without ſcruple by the higheſt and loweſt. Another cuſtom, ſtill more extraordinary, is, that no woman is allowed *to eat an egg*. This prohibition, whether ariſing from ancient ſuperſtition, or from the craftineſs of ſome old Buſhreen who loved eggs himſelf, is rigidly adhered to; and nothing will more affront a woman of Teeſee than to offer her an egg. The cuſtom is the more ſingular, as the men eat eggs without ſcruple in the preſence of their wives, and Mr Park never obſerved the ſame prohibition in any other of the Mandingo countries.

Our author was preſent at a palaver held by the governor of Teeſee on a very extraordinary occaſion; of which we ſhall give his account at full length, becauſe it ſhows how free men are reduced to ſlavery in North Africa. "The caſe was this. A young man, a Kafir, of conſiderable affluence, who had recently married a young and handſome wife, applied to a very devout Buſhreen, or Muſſulman prieſt, of his acquaintance, to procure him ſaphies for his protection during the approaching war. The Buſhreen complied with the requeſt; and in order, as he pretended, to render the ſaphies more efficacious, enjoined the young man to avoid any nuptial intercourſe with his bride for the ſpace of ſix weeks. Severe as the injunction was, the Kafir ſtrictly obeyed; and without telling his wife the real cauſe, abſented himſelf from her company. In the mean time it began to be whiſpered at Teeſee, that the Buſhreen, who always performed his evening devotions at the door of the Kafir's hut, was more intimate with the young wife than he ought to be. At firſt, the good huſband was unwilling to ſuſpect the honour of his ſanctified friend, and one whole month elapſed before any jealouſy roſe in his mind; but hearing the charge repeated, he at laſt interrogated his wife on the ſubject, who frankly confeſſed that the Buſhreen had ſeduced her. Hereupon the Kafir put her into confinement, and called a palaver upon the Buſhreen's conduct. The fact was clearly proved againſt him; and he was ſentenced to be ſold into ſlavery, or to find two ſlaves for his redemption, according to the pleaſure of the complainant. The injured huſband, however, was unwilling to proceed againſt his friend to ſuch extremity, and deſired rather to have him publicly flogged before the governor's gate. This was agreed to, and the ſentence was immediately executed. The culprit was tied by the hands to a ſtrong ſtake; and a long black rod being brought forth, the executioner, after flouriſhing it round his head for ſome time, applied it with ſuch force and dexterity to the Buſhreen's back, as to make him roar until the woods reſounded with his ſcreams. The ſurrounding multitude, by their hooting and laughing, manifeſted how much they enjoyed the puniſhment of this old gallant; and it is worthy of remark, that the number of ſtripes was preciſely the ſame as are enjoined by the Moſaic law, *forty, ſave one*."

The method of converting the negro nations to the

Kaſſon.

Kaſſon, Keate.

religion of the Arabian Impoſtor is a very ſingular one; and Mr Park ſaw the whole people of Teeſee converted in an inſtant. During his reſidence in that town an embaſſy of ten people belonging to Almami Abdulkader, king of Foota Torra, a country to the weſt of Bondou, arrived at Teeſee; and deſiring Tiggity Sego the governor to call an aſſembly of the inhabitants, announced publicly their king's determination, to this effect: "That unleſs all the people of Kaſſon would embrace the Mahomedan religion, and evince their converſion by ſaying eleven public prayers, he (the king of Foota Torra) could not poſſibly ſtand neuter in the preſent conteſt, but would certainly join his arms to thoſe of Kajaaga." A meſſage of this nature, from ſo powerful a prince, could not fail to create great alarm; and the inhabitants of Teeſee, after a long conſultation, agreed to conform to his good pleaſure, humiliating as it was to them. Accordingly, one and all publicly offered up eleven prayers, which were conſidered a ſufficient teſtimony of their having renounced Paganiſm, and embraced the doctrines of the Prophet.

Our author relates a ſtory, which we cannot refuſe ourſelves the pleaſure of inſerting, becauſe it exhibits a very pleaſing picture of the affection and gratitude of the Pagan negroes. In his train was a blackſmith, who had lived ſome years on the Gambia, and who now returned to his own country *Kaſſon*. "Soon after we came in ſight of Jumbo, his native town (ſays Mr Park), his brother, who had by ſome means been appriſed of his coming, came out to meet him, accompanied by a ſinging man: he brought a horſe for the blackſmith, that he might enter his native town in a dignified manner; and he deſired each of us to put a good charge of powder into our guns. The ſinging man now led the way, followed by the two brothers; and we were preſently joined by a number of people from the town, all of whom demonſtrated great joy at ſeeing their old acquaintance the blackſmith, by the moſt extravagant jumping and ſinging. On entering the town, the ſinging man began an extempore ſong in praiſe of the blackſmith, extolling his courage in having overcome ſo many difficulties; and concluding with a ſtrict injunction to his friends to dreſs him plenty of victuals.

"When we arrived at the blackſmith's place of reſidence, we diſmounted and fired our muſkets. The meeting between him and his relations was very tender; for theſe rude children of nature, free from reſtraint, diſplay their emotions in the ſtrongeſt and moſt expreſſive manner. Amidſt theſe tranſports, the blackſmith's aged mother was led forth, leaning upon a ſtaff. Every one made way for her; and ſhe ſtretched out her hand to bid her ſon welcome. Being totally blind, ſhe ſtroked his hands, arms, and face, with great care, and ſeemed highly delighted that her latter days were bleſſed by his return, and that her ears once more heard the muſic of his voice. From this interview I was fully convinced, that whatever difference there is between the Negro and European in the conformation of the noſe and the colour of the ſkin, there is none in the genuine ſympathies and characteriſtic feelings of our common nature.

"During the tumult of theſe congratulations, I had ſeated myſelf apart, by the ſide of one of the huts, being unwilling to interrupt the flow of filial and parental tenderneſs; and the attention of the company was ſo entirely taken up with the blackſmith, that I believe none of his friends had obſerved me. When all the people preſent had ſeated themſelves, the blackſmith was deſired by his father to give them ſome account of his adventures; and ſilence being commanded, he began; and after repeatedly thanking God for the ſucceſs that had attended him, related every material occurrence that had happened to him from his leaving Kaſſon to his arrival at the Gambia; his employment and ſucceſs in thoſe parts; and the dangers he had eſcaped in returning to his native country. In the latter part of his narration, he had frequently occaſion to mention me; and after many ſtrong expreſſions concerning my kindneſs to him, he pointed to the place where I ſat, and exclaimed, *affille ibi ſiring*, "ſee him ſitting there." In a moment all eyes were turned upon me; I appeared like a being dropped from the clouds; every one was ſurpriſed that they had not obſerved me before; and a few women and children expreſſed great uneaſineſs at being ſo near a man of ſuch an uncommon appearance. By degrees, however, their apprehenſions ſubſided; and when the blackſmith aſſured them that I was perfectly inoffenſive, and would hurt nobody, ſome of them ventured ſo far as to examine the texture of my clothes; but many of them were ſtill very ſuſpicious; and when by accident I happened to move myſelf, or look at the young children, their mothers would ſcamper off with them with the greateſt precipitation. In a few hours, however, they all became reconciled to me." With theſe worthy people our author ſpent the greater part of two days in feaſting and merriment; the blackſmith accompanied him to the capital; and declared, that he would not leave him while he reſided there.

KEATE (George, Eſq; F. R. S.), deſcended of an ancient and honourable family, was born about the year 1729 or 1730, and received his education at Kingſton ſchool, under the Rev. Mr Woodeſon. From thence he went to Geneva, where he reſided ſome years; and during his ſtay there, became acquainted with Voltaire, with whom he continued to correſpond many years after he returned to England. After finiſhing the tour of Europe, he ſettled as a ſtudent in the Inner Temple, was called to the bar, and ſometimes attended Weſtminſter Hall; though he did not meet with encouragement enough to induce his perſeverance in his profeſſion, nor indeed does it ſeem probable that he had ſufficient application for it. His firſt literary performance was "Ancient and Modern Rome," a poem, written at Rome in the year 1755, printed in the year 1760, and received with conſiderable applauſe. The next year he publiſhed "A Short Account of the Ancient Hiſtory, Preſent Government, and Laws, of the Republic of Geneva, 8vo." This work was compiled during the author's reſidence at Geneva; is a very uſeful one; and is dedicated to Monſieur de Voltaire; to whom he ſays, "When I reflect, that it was in this Republic, whoſe government I have attempted to deſcribe, that I was firſt introduced to your acquaintance; when memory renews the hours of ſocial mirth and refined entertainment which your hoſpitality and converſation afforded me—I cannot but rejoice in this occaſion of expreſſing my gratitude; proud that, as your friendſhip diſtinguiſhed the author of theſe pages in a foreign country, your name may at home adorn his labour."

It was at one time the intention of Voltaire to tranſlate this account into French, though he afterwards relinquiſhed the deſign.

The next year, 1762, he produced an "Epiſtle from Lady Jane Gray to Lord Guildford Dudley :" and in 1763, "The Alps," a poem ; the ſubject of which comprehends all that chain of mountains known under the general name of the Alps, extending from Italy to Germany, and from France to Tyrol, by whatever denomination they are particularly diſtinguiſhed. Of all the poetical works of Mr Keate, this is intitled to the higheſt praiſe for truth of deſcription, elegance of verſification, and vigour of fancy.

Continuing to employ the preſs, in 1764 he publiſhed "Netley Abbey," which he afterwards, in 1769, enlarged and reprinted : and, in 1765, produced "The Temple Student, an Epiſtle to a Friend ;" humourouſly rallying his own want of application to the ſtudy of the law, his preference of the belles lettres, and his conſequent want of ſucceſs in his profeſſion. The death of Mrs Cibber in 1766, of whoſe merits as an actreſs he entertained the higheſt opinion, gave occaſion for a poem to her memory, which celebrates her excellent performances on the ſtage, and laments the loſs the theatre would ſuſtain by her death.

In February 1769, he married Miſs Hudſon ; and about the ſame time publiſhed "Ferney ; an Epiſtle to M. de Voltaire" In this poem, after praiſing with energy the various beauties of his friend's poetical works, he introduces the following panegyric on Shakeſpeare :

Yes ! jealous wits may ſtill for empire ſtrive,
Still keep the flames of critic rage alive :
Our Shakeſpeare yet ſhall all his rights maintain,
And crown the triumphs of Eliza's reign.
Above controul, above each claſſic rule,
His tut'reſs Nature, and the world his ſchool,
On ſoaring pinions borne, to him was given
Th' ærial range of Fancy's brighteſt heav'n ;
To bid wrapt thought o'er nobleſt heights aſpire,
And wake each paſſion with a muſe of fire.
Revere his genius. To the dead be juſt,
And ſpare the laurels that o'erſhade the duſt.
Low ſleeps the bard, *in cold obſtruction laid*,
Nor aſks the chaplet from a rival's head.
O'er the drear vault, Ambition's utmoſt bound,
Unheard ſhall Fame her airy trumpet ſound !
Unheard alike ; nor grief nor tranſport raiſe
The blaſt of cenſure, or the note of praiſe !
As Raphael's own creation grac'd his hearſe,
And ſham'd the pomp of oſtentatious verſe,
Shall Shakeſpeare's honours by himſelf be paid,
And Nature periſh ere his pictures fade.

This eulogium on Shakeſpeare, in an an epiſtle to Voltaire, who had laboured ſo long and ſo ſtrenuouſly to detract from the merit of our immortal bard, ſhews that Mr Keate had not given up his judgment to the ſage of Ferney. How the old and envious ſophiſter would reliſh his friend's conduct, may be eaſily conceived. His feelings were certainly very different from thoſe of the mayor and burgeſſes of Stratford, when, in conſequence of this panegyric on their townſman, they complimented Mr Keate with a ſtandiſh, mounted with ſilver, made out of the famous Mulberry tree planted by Shakeſpeare.

In 1773, he publiſhed "The Monument in Arcadia," a dramatic poem, built on the picture of Pouſſin, mentioned by Abbé du Bos in his "Critical Reflections on Poetry and Painting."

In 1779, Mr Keate produced one of his moſt ſucceſsful works, intitled "Sketches from Nature ; taken and coloured in a Journey to Margate," 2 vols, 12mo. This performance, allowing it to be, as it really is, an imitation of Sterne's "Sentimental Journey ;" yet contains ſo many pleaſing delineations of life, ſo many ſtrokes of humour, and ſo much elegance of compoſition, that few will heſitate to give it the preference to any other of Sterne's imitators.

In 1781, he collected his poetical works in two vols, 12mo, and added ſeveral new pieces not before printed. The principal of theſe was "The Helvetiad," a fragment, written at Geneva in the year 1756. In the preface to this performance he gives the following account of it : "During a long ſtay I many years ſince made at Geneva, I viſited moſt of the principal places in Switzerland. The many ſublime ſcenes with which nature hath enriched this romantic country ; the tranquillity and content with which every individual enjoys his property ; and, above all, that independence of mind which is ever the reſult of liberty—animated me with ſuch veneration for the firſt authors of that freedom, whoſe figures are recorded to poſterity either by ſculpture or painting in the public parts of the towns thro' thoſe little ſtates, that my enthuſiaſm betrayed me into a deſign of writing a poem on this ſingular revolution ; the argument of which I had divided into *ten cantos*, beginning the work with the oppreſſions of the Houſe of Auſtria, and cloſing it with the battle of Mongarten ; by which thoſe injured people finally renounced its uſurpation, and formed among themſelves thoſe various confederacies that ended in the great union and alliance of the preſent *thirteen cantons*. When I had ſettled the whole plan of this work, I occaſionally, as I found a diſpoſition in myſelf, took up any part of the poem which at the moment moſt invited my thoughts : and enjoying at this time ſuch an intercourſe with M. de Voltaire as afforded me a conſtant acceſs to him, I acquainted him with my intention, ſhewing him the argument I had drawn out for the conduct of the whole deſign. He kept it a few days ; and, in returning it, told me, that he thought the great object of the piece, the epiſodes connected with the hiſtory, together with the ſcenery of the country, preſented ſubject matter whereon to form a fine poem ; "but the time (added he) which ſuch an undertaking will require, I would rather counſel you to employ on ſubjects that might more engage the public attention ; for ſhould you devote yourſelf to the completion of your preſent deſign, the Swiſs would be much obliged to you, without being able to read you, and the reſt of the world care little about the matter." Feeling the force and juſtneſs of the remark, Mr Keate laid aſide his plan, and probably never reſumed it. In the ſame year, 1781, he publiſhed "An Epiſtle to Angelica Kauffman."

A few years after, he became engaged in a long and vexatious law-ſuit, in conſequence of the neglect (to ſay the leaſt of it) of an architect who profeſſed himſelf to be his friend ; the particulars of which it is of no importance to detail. At the concluſion of the buſineſs, he ſhewed that his good humour had not forſaken him :

And in 1787 he gave to the public the principal circumſtances of his caſe in a performance, intitled, "The Diſtreſſed Poet, a ſerio-comic Poem, in three Cantos," 4to, with ſome pleaſantry, and without any acrimony.

His laſt work did infinite honour to his head and his heart, as well as to the liberality of the bookſeller for whom on the title-page it was ſaid to be publiſhed. In the year 1782, the Antelope packet was ſhipwrecked on the Pelew iſlands, where the commander, Captain Wilſon, and his crew lived ſome time before they could get off. On his return to England, the Captain was, for ſome reaſon or other, refuſed the command of another ſhip; and, as we have been informed, he was reduced to a ſtate much the reverſe of affluence. Theſe circumſtances being communicated to Mr Keate, who was ſtruck with admiration of the manners of the inhabitants of the Pelew iſlands (See Pelew Islands, *Encycl.*), he offered to draw up, for the benefit of Captain Wilſon, a narrative of the occurrences which took place during that officer's reſidence among ſo ſingular a people. This he executed in "An Account of the Pelew Iſlands, ſituated in the Weſtern Part of the Pacific Ocean; compoſed from the Journals and Communications of Captain Henry Wilſon and ſome of his Officers, who in Auguſt 1783 were there ſhipwrecked, in the Antelope, a Packet belonging to the Honourable the Eaſt India Company," 4to; a work written with great elegance, compiled with much care, and which, if embelliſhed (as it has been inſinuated) with facts better calculated to have found a place in a novel than a genuine narrative, muſt be aſcribed to the miſinformation of thoſe who were actors in the ſcene, and muſt firſt have deceived before they obtained credit. We mention this report as it has come to us, without any attempt either to eſtabliſh or refute it. We ſhall only add, that if the charge is well founded, Mr Keate (who undertook the taſk on the moſt diſintereſted principle, and derived no advantage whatever from the work) was too ſturdy a moraliſt to have had any hand in the impoſition.—The manuſcript was offered to Mr Dodſley for 300 guineas; but he heſitated to give for it ſo large a price, when another bookſeller undertook to publiſh the work for the benefit of Mr Wilſon; and, we have reaſon to believe, paid to that gentleman, within the compaſs of a year, triple the ſum for which the manuſcript had been offered to Dodſley. Such conduct reflects honour on the London trade.

Beſides the pieces already mentioned, Mr Keate was the author of many Prologues and Epilogues, ſpoken at Mr Newcomb's ſchool at Hackney. He adapted his friend Voltaire's "Semiramis" to the ſtage; but this was ſuperſeded in 1777 at Drury Lane, by a worthleſs tranſlation of as worthleſs an author, one Captain Ayſcough; but neither this nor the author are deſerving of any further notice.

We ſhall conclude by obſerving, that Mr Keate's life paſſed without any viciſſitudes of fortune; he inherited an ample eſtate, which he did not attempt to increaſe otherwiſe than by thoſe attentions which prudence dictated in the management of it. He was hoſpitable and beneficent, and poſſeſſed the good-will of mankind in a very eminent degree. For the laſt year or two, his health viſibly declined; but on the day he died, it appeared to be ſomewhat mended. His death was ſudden, on the 27th of June 1797. He left one daughter, married in 1796 to John Henderſon, Eſq; of the Adelphi. At the time of his death, Mr Keate was a Bencher of the Temple, and a very old member of the Royal and Antiquary Societies, of both of which he had been frequently elected one of the council.

KENNICOTT (Dr Benjamin) was a man of ſuch eminence in the learned world, that every thing relating to him muſt be generally intereſting. In the biographical ſketch of him publiſhed in the *Encyclopædia*, we have acknowledged ourſelves unacquainted with the rank and character of his parents; but this information has been ſince ſupplied by a very candid and well-informed writer in the Monthly Magazine; and as it is accompanied with circumſtances peculiarly honourable to the Doctor, and ought therefore to be preſerved, we ſhall inſert it in this place.

"The parents of Dr Kennicott (ſays this writer) were honeſt characters: His father was the pariſh clerk of Totneſs, and once maſter of a charity ſchool in that town. At an early age young Kennicott ſucceeded to the ſame employ in the ſchool, being recommended to it by his remarkable ſobriety and premature knowledge. It was in that ſituation he wrote the verſes to the honourable Mrs Courtney, which recommended him to her notice, and that of many neighbouring gentlemen. They, with a laudable generoſity, opened a ſubſcription to ſend him to Oxford.

"He ſoon there diſtinguiſhed himſelf, as is well known. As a teſtimony of the truth of the above ſtatement, the following is a copy of an inſcription written by Dr Kennicott, and engraved on the tomb of his father and mother. The writer of this article has tranſcribed it from the original in the church-yard of Totneſs. The tomb is more elegant than perſons in their ſituation are accuſtomed to have erected, and was thought, perhaps, by the envious to be ſomewhat oſtentatious. A perſonal knowledge of the Doctor induces the writer of this article to think, that it was rather the tribute of a good and grateful mind, and of the pious reverence and love which he entertained for the authors of his being.

As Virtue ſhould be of good report,
ſacred
be this humble Monument
to the Memory of
Benjamin Kennicott, Pariſh Clerk of Totneſs,
and Elizabeth his Wife:
The latter
an Example of every Chriſtian Duty;
The former,
animated with the warmeſt Zeal,
regulated by the beſt good ſenſe,
and both conſtantly exerted
for the Salvation of himſelf and others.
Reader!
Soon ſhalt thou die alſo;
and as a Candidate for Immortality
ſtrike thy breaſt and ſay,
Let me live the life of the Righteous,
that my laſt end may be like his.
Trifling are the dates of Time
where the ſubject is Eternity.
Erected
by their Son, B. Kennicott, D. D.
Canon of Chriſt-Church, Oxford.

"It is ſaid, that when Dr Kennicott had taken orders, he came to officiate in his clerical capacity in his native town. When his father as clerk proceeded to place the ſurplice on his ſhoulders, a ſtruggle enſued between the modeſty of the ſon and the honeſt pride of the parent, who inſiſted on paying that reſpect to his ſon which he had been accuſtomed to ſhew to other clergymen: to this filial obedience was obliged to ſubmit. A circumſtance is added, that his mother had often declared ſhe ſhould never be able to ſupport the joy of hearing her ſon preach; and that on her attendance at the church for the firſt time, ſhe was ſo overcome as to be taken out in a ſtate of temporary inſenſibility."

KERMES (ſee *Coccus Ilicis*, Encycl.) has been proved by Profeſſor Beckmann to have been uſed as a dye from very remote antiquity. "All the ancient Greek and Latin writers, he ſays, agree, that kermes, called by the latter *coccum*, perhaps alſo *coccus*, and often *granum*, were found upon a low ſhrubby tree, with prickly leaves, which produced acorns, and belonged to the genus of the oak; and there is no reaſon to doubt that they mean *coccum ilicis*, and that low ever green oak, with the prickly leaves of the holly (*aquifolium*), which is called at preſent in botany *quercus ilex*. This aſſertion appears more intitled to credit, as the ancients aſſign for the native country of this tree places where it it is ſtill indigenous, and produces kermes.

"I am inclined (continues our author) to believe, that the art of employing kermes to dye a beautiful red colour was diſcovered in the Eaſt at a very early period; that it was ſoon ſo much improved as to excel even he Tyrian purple; and that it contributed to cauſe the proper purple to be at length abandoned. From the coſtly red dyes extolled ſo much by the Hebrew writers, and which, according to the opinion of learned commentators, were made from kermes, I ſhall not venture to adduce any proofs, as I am not acquainted with the Oriental languages to examine their accounts with accuracy; but I have found a paſſage in Vopiſcus, which ſeems to render my conjecture very probable. That author informs us, that the king of Perſia ſent to the Emperor Aurelian, beſides other articles of great value, ſome woollen cloth, which was of a much coſtlier and brighter purple colour than any that had been ever ſeen in the Roman empire, and, in compariſon of which, all the other purple cloth worn by the Emperor and the ladies of the court appeared dull and faded. In my opinion, this cloth, which was of a beautiful purple red colour, was not dyed with the liquor of the murex, but with kermes. This idea was indeed not likely to occur to the Romans, who were acquainted only with the purple of the murex, and who had leſs experience in the arts in general than in that of robbing and plundering, or who, at any rate, in that reſpect were inferior to the Orientals. The Roman emperors cauſed this ſuppoſed purple to be ſought for in India by the moſt experienced dyers; who, not being able to find it, returned with a vague report that the admired Perſian purple was produced by the plant ſandix. I am well aware, that ſome commentators have ſuppoſed that the ſandix was our madder. Heſychius, however, ſays, very confidently, that the *ſandix* is not a plant, but a kind of ſhrubby tree, which yields a dye like the *coccus*. The Roman dyers, perhaps prejudiced in favour of the murex, made that only the object of their ſearch; and their labour proving fruitleſs, they might have heard ſomething of kermes, or the kermes-oak, which they did not fully underſtand. Our dyers, even at preſent, believe many falſe accounts reſpecting the dye-ſtuffs which they uſe daily."

The uſe of kermes in dyeing ſeems to have been continued through every century. In the middle ages, as they are called, we meet with kermes under the name of *vermiculus* or *vermiculum*; and on that account cloth dyed with them was called *vermiculata*. Hence the French word *vermeil*, and its derivative *vermilion*, as is well known, had their extraction; the latter of which originally ſignified the red dye of kermes, but it is now uſed for any red paint, and alſo for fine pounded cinnabar.

KHAS, in Bengal, lands taken into the hands of government, oppoſed to the management of Zemindars or farmers. See ZEMINDAR in this *Supplement*.

KHALSA, in Bengal, ſometimes with the addition of *Shereeſah*, the department of land and revenues; the exchequer.

KHERAJE, in Bengal, ſignifies ſtrictly the tribute paid by a conquered country: it is alſo uſed for revenue in general.

KHIDMUT, office, attendance, employment, ſervice.

KHIDMUTGAR, a waiting man.

KHISMUT, portion or diviſion.

KHOMAR, or COMAR, a Zemindar's demeſne land.

KING-POST, or KING-*Piece*, is a piece of timber ſet upright in the middle, between two principal rafters, and having ſtruts or braces going from it to the middle of each rafter. See ROOF, *Encycl.*; and CARPENTRY, *Suppl.*

KIPPIS (Andrew, D. D. F. R and A. S.), was born at Nottingham, March 28 (O. S.) 1725. His father, a reſpectable tradeſman of that town, was deſcended from the Rev. Benjamin King of Oakham, Rutlandſhire, an ejected miniſter; and his mother, Ann Ryther, was the grand-daughter of the Rev. John Ryther, who was ejected from the church of Fernby, in the county of York. In the year 1730, he loſt his father, and went to reſide with his grandfather, Andrew Kippis of Seaford in Lincolnſhire. He received his claſſical education at the grammar ſchool in that town; but what contributed moſt to his future eminence, was the friendſhip of the Rev. Mr Merrival, who was equalled by few of his contemporaries in various branches of learning, particularly in his acquaintance with the claſſics, his knowledge of ancient and modern hiſtory, and his refined taſte in the belles lettres. Dr Kippis frequently ſaid, that it was impoſſible for him to expreſs his obligations to this friend of his youth. In 1741 he removed to Northampton, and commenced his academical ſtudies under Dr Doddridge. After a reſidence of five years at the academy, he was invited by ſeveral congregations to become their miniſter. Though he was preſſed to ſettle at Dorcheſter, and had been choſen their miniſter, he gave the preference to an invitation from Boſton in Lincolnſhire, where he went to reſide in September 1746. Here he continued four years; and in November 1750, accepted the paſtoral charge of a congregation at Dorking in Surry. The congregation meeting in Princes-ſtreet Weſtminſter, having been without a miniſter about two years, he was choſen, in June 1753, to ſucceed the Rev. Dr Obadiah Hughes. On the 21ſt of September following, he married, at Boſton, Miſs Elizabeth Bott, one of the daughters of Mr Iſaac Bott, a merchant of that place; and in the month of October fixed his reſidence in Weſtminſter. In June 1767, he received the degree of D. D. from the univerſity of Edinburgh, on the unſolicited recommendation of the late learned Profeſſor Robertſon. He was elected a member of the Society of Antiquaries on the 19th of March 1778; and on the 17th of June 1779, he was choſen a Fellow of the Royal Society. In both Societies he had the honour of being in the council two years.

Dr Kippis was eminently diſtinguiſhed for the virtues and accompliſhments which form the chief ornaments of private life. With a ſuavity of manners and urbanity of behaviour peculiarly attractive, he united that knowledge of men and books which rendered his converſation uncommonly entertaining and inſtructive to the circle of his acquaintance and friends. As a miniſter, he was not leſs eminent for his profound acquaintance with every branch of theology than for the happy manner in which he applied it to the improvement of thoſe who attended his miniſtry. His ſermons were remarkable for perſpicuity, elegance, and energy; and his elocution was unaffected and very impreſſive, particularly at the cloſe of his diſcourſes. But the ſuperior powers and vigour of mind which he derived from nature, and which he had cultivated with unremitting diligence and peculiar ſucceſs, were not to be confined to the narrow limits of private life and the duties of the paſtoral charge, however important; they were deſigned for more extenſive and important ſervices to his country and to mankind. The intereſts of literature, ſcience, and religion, have received from the exertion of his talents as a writer the moſt eſſential advantages. His firſt efforts in literature were made in the Gentleman's Magazine, a periodical publication called the Library, and the Monthly Review; to each of which he contributed many important articles, eſpecially in the hiſtorical and philological departments of the laſt. He was the author of three important tracts, viz "A Vindication of the Proteſtant Diſſenting Miniſters, &c." "Obſervations on the late Conteſts in the Royal Society;" and "Conſiderations on the Treaty with America, &c." His improved edition of Dr Doddridge's Lectures is a work of great value; and "The Hiſtory of Knowledge, Learning, and Taſte, in Great Britain," prefixed to the New Annual Regiſter, merits, and has received, the approbation of the public. He publiſhed at different times ſeveral ſingle ſermons; among which, that on the death of his friend the Rev. Mr Laugher, is intitled to very high praiſe. The greater part of theſe he republiſhed, with other practical diſcourſes, in the year 1794: but the work which, next to the ſtudies immediately connected with his office as a Chriſtian miniſter, engaged his principal attention, and by which he has long been diſtinguiſhed, is, the improved edition of the "*Biographia Britannica*." In this great national publication, the comprehenſiveneſs and powers of his mind, the correctneſs of his judgment, the vaſt extent of his information, his indefatigable reſearches and unremitting aſſiduity, his peculiar talent of appreciating the merits, and analyzing the labours of the moſt eminent writers, and his unſhaken integrity, unbiaſſed fidelity, and impartial deciſion on the characters of the philoſopher, ſtateſman, poet, ſcholar, and divine, are ſtrongly diſplayed, and univerſally acknowledged. His ſtyle, formed on the models of Sir William Temple and the claſſical Addiſon, is remarkable for its perſpicuity, elegance, and purity; and gives a peculiar luſtre to the rich ſtores of knowledge treaſured in the volumes now publiſhed. This work has given him a high rank among the literati of his country, and will carry down his name with diſtinguiſhed reputation to poſterity. He died on the 8th October 1795.

KOL-QUALL, the Abyſſinian name of a tree, which ſome botaniſts have ſuppoſed to be the EUPHORBIA *Officinarum* of Linnæus. Mr Bruce, who gives the only deſcription of the Kol-quall that we have ſeen, is of a different opinion: for which he aſſigns two reaſons; the firſt is, that the flower, which he ſays is roſaceous, is compoſed of ſeveral petals, and is not companiform; and the ſecond, that it produces no ſort of gum, either ſpontaneouſly or upon inciſion. We muſt acknowledge, that we entertain ſome doubts whether our author was at due pains to aſcertain this fact; and theſe doubts are ſuggeſted by his own hiſtory of the tree. His deſcription is not very perſpicuous, and therefore, leſt we ſhould miſrepreſent his meaning, we ſhall give it in his own words:

"The firſt thing that preſented itſelf was the firſt ſhoot of this extraordinary tree. It was a ſingle ſtalk, about ſix inches meaſured acroſs, in eight diviſions, regularly and beautifully ſcolloped and rounded at the top, joining in the centre at three feet and a half high. Upon the outſide of theſe ſcollops were a ſort of eyes or ſmall knots, out of every one of which came five horns, four on the ſides and one in the centre, ſcarce half an inch long, fragil, and of no reſiſtance, but exceedingly ſharp and pointed. Its next proceſs is to put out a branch from the firſt or ſecond ſcollop near the top, others ſucceed from all directions; and this ſtalk, which is ſoft and ſucculent, of the conſiſtence of the aloe, turns by degrees hard and ligneous, and after a few years, by multiplying its branches, aſſumes the form of a tree, the lower part of which is wood, the upper part, which is ſucculent, has no leaves; theſe are ſupplied by the fluted, ſcolloped, ſerrated, thorny ſides of its branches. Upon the upper extremity of theſe branches grow its flowers, which are of a golden colour, roſaceous, and formed of five round or almoſt oval petala; this is ſucceeded by a triangular fruit, firſt of a light green with a ſlight caſt of red, then turning to a deep crimſon, with ſtreaks of white both at top and bottom. In the inſide it is divided into three cells, with a ſeed in each of them; the cells are of a greeniſh white, the ſeed round, and with no degree of humidity or moiſture about it; yet the green leaves contain a quantity of bluiſh watery milk almoſt incredible.

"Upon cutting two of the fineſt branches of a tree in its full vigour, a quantity of this iſſued out, which I cannot compute to be leſs than four Engliſh gallons; and this was ſo exceedingly cauſtic, that though I waſhed the ſabre that cut it immediately, the ſtain has not yet left it.

"When the tree grows old, the branches wither, and, in place of milk, the inſide appears to be full of powder, which is ſo pungent, that the ſmall duſt which I drew upon ſtriking a withered branch, ſeemed to threaten to make me ſneeze to death, and the touching of the milk with my fingers excoriated them as if ſcalded with boiling water; yet I everywhere obſerved the wood-pecker piercing the rotten branches with its beak, and eating the inſects, without any impreſſion upon its olfactory nerves."

If what is milk in a young tree be a dry powder in one that is old, is it not probable that the milk might by evaporation be reduced to the conſiſtence of gum, and that the kol quall may be at moſt but a variety of the *euphorbia officinarum?* From our author's obſervation, the kol-quall appeared to thrive beſt on poor, ſandy, ſtony earth, at no great diſtance from the ſea. The Abyſſinians employ the milky juice in tanning to take off the hair from the ſkins, and they make no other uſe whatever of the tree.

KOONA, a ſpecies of ECHITES (for which ſee *Encycl.*), very common in the woods of North Africa. It is a ſhrub, of which the leaves, when boiled with a ſmall quantity of water, yield a thick black juice, into which the negroes dip a cotton thread. This thread they faſten round the iron of their arrows, in ſuch a manner that it is almoſt impoſſible to extract the arrow when it has ſunk beyond the barbs, without leaving the iron and the poiſoned thread in the wound. The poiſon of the koona is ſaid to be very deadly.—*Park's Travels.*

KORAQUAS, a tribe of Hottentots inhabiting a diſtrict of South Africa, which M. Vaillant places on the confines of the Nimiqua country (See NIMIQUAS, *Suppl.*). When our author viſited them, the whole tribe was aſſembled for the election of a chief: and not agreeing among themſelves, ſome blood had been ſhed, and much more would have been ſhed, had they not unanimouſly made choice of him. When he firſt joined them, the whole horde paid attention to nothing but their quarrel. To ſee their warmth, one might have ſuppoſed that their election was a matter of importance to the whole world, and that the fate of mankind was about to depend on their chief. All ſpoke at the ſame time; each endeavoured to drown his neighbour's voice by his own; their eyes ſparkled with fury; and amidſt this confuſion, while they threatened each other in turns, the noiſe they made became truly dreadful.

Unarmed, and without any precaution, though ſurrounded by this enraged multitude, our author walked calmly along in the midſt of them; and when he reached the kraal, he ordered his tent to be immediately formed, as if he had been ſurrounded by friends and relations. This appearance, raiſed ſuddenly, and as if by magic, before the eyes of the horde, with his fuſees, horſes, and tent, objects which were all new to them, filled them with admiration. Men, women, and children, motionleſs, and with their mouths wide open, all ſtood looking at them with profound ſilence. Anger, hatred, and every violent paſſion, ſeemed by their countenances to be extinguiſhed, and to have given place to more tranquil emotions, to ignorant ſurpriſe, and ſtupid aſtoniſhment. Infancy is naturally curious; it is ſtruck with every thing it ſees; and the ſavage, in this reſpect, is only a grown-up child. As theſe ſavages ſeemed to wiſh that he would permit them to examine more cloſely whatever excited their admiration, he readily condeſcended to gratify their deſire. They approached, ſurveyed, and handled every thing. But the principal object of general curioſity was his perſon. They ſeemed as if they would never be ſatisfied with looking at his dreſs. They pulled off his hat, that they might the better examine his hair and his beard, which were long. They even half unbuttoned his clothes; and ſurpriſed to ſee his ſkin white, each felt it, as if deſirous to aſcertain that what they ſaw was real.

This comedy continued till the evening; and at length, when the moment of ſeparation arrived, M. Vaillant cauſed to be hinted to the whole company, that if, two hours after ſun riſe next morning, they ſhould not be agreed reſpecting the choice of a chief, he would immediately leave them. He added, however, that if, on the other hand, they came and preſented to him a chief, elected by general conſent, he would then load them all with preſents, and beſtow on him a diſtinction which would raiſe him above all his equals, and render the horde one of the moſt celebrated in the whole country. "But what was my ſurpriſe (ſays he) when I learned the ſame evening, that on my head the burden of the crown was depoſed!" He acquieſced, however; aſſuring them, that if they would promiſe to be obedient, he would give them the only chief worthy of ruling them, and of making them happy.

By his interpreters he had learned, that the choice of the majority leaned towards one Haripa, a man about 40 years of age; tall, well made, exceedingly ſtrong, and conſequently formed by nature for ruling the feeble multitude. He therefore named Haripa chief; and the people appearing to approve of his choice, he commanded ſilence, and cauſing the new monarch to approach, placed on his head, with great ſolemnity, a Dutch grenadier cap, of which the copperplate on the front was ornamented with the arms of Holland. This ſymbol, *viz.* a lion rampant, having in one of his fore-paws ſeven arrows, and in the other a naked ſabre, could not fail to pleaſe the ſavages, as it exhibited a repreſentation of the weapons peculiar to them, and of the moſt formidable animal of their country. They teſtified their admiration in the moſt expreſſive manner; and imagined that, ſuperior to kings, the white man during the night had by magic made this crown, merely to adorn their chief, and to afford them pleaſure. Vaillant then affixed to the ſkin, which formed Haripa's dreſs, ſeveral rows of glaſs beads; gave him a girdle made of a ſtring of very large ones; ornamented his arms with tin bracelets, and ſuſpended from his neck a ſmall padlock, ſhaped like a butterfly, the key of which had been loſt. Such padlocks, made in the form of animals of every kind, are very common at the Cape. They come from China; and are brought to Africa by the captains of the Company's ſhips which trade in the Indian ſeas.

During the ceremony of inſtallation, the whole horde, dumb and motionleſs through admiration, ſeemed loſt in ecſtacy. Haripa himſelf, though highly gratified, did not dare to make the leaſt movement, and obſerved a gravity altogether riſible. When the inauguration was finiſhed, and he was completely dreſſed, our author preſented him with a mirror, that he might enjoy the ſatiſfaction of ſurveying his own figure. He then ſhewed him to the people, who expreſſed their joy by ſhouts and applauſes without end.

"Ye honeſt hearts (ſays M. Vaillant), who peruſe this account, behold what it coſt me to reſtore peace among

Koraquas.

among a whole tribe, and to prevent them from deſtroying each other!" From this moment concord was re-eſtabliſhed; univerſal joy prevailed through the horde; and they inſtantly began their dancings, which continued for three days and three nights without intermiſſion. They killed for this feſtival ſeveral fat ſheep, and even two oxen; an extraordinary and truly aſtoniſhing magnificence among a people who, when they barter one of their daughters for a cow, think they have made an excellent bargain.

Our author, wiſhing to purchaſe ſome oxen for his waggons, bought them at the price of a nail the ox; and thoſe who had the good fortune to make ſuch an exchange were highly ſatisfied with their bargain. Nails and ſmall bits of iron were indeed of real value to them, to point the arrows and aſſageys with which they ſhot the antelopes that abound in their country, and conſtitute much of their food. Like other ſavages, the Koraquas were ready to pilfer, and appropriate to their own uſe whatever they found pleaſing, or ſuited to their purpoſes. They attempted to carry away ſome of our author's effects, even before his face; and to prevent their rapacity, he was obliged either to watch over, or to depoſit them in ſome place of ſafety.

The Koraquas are much taller than the Hottentots of the colonies, though they appeared evidently to be deſcended from the ſame race, having the ſame language and cuſtoms with their neighbours the Nimiquas (ſee that article), who are certainly of Hottentot extraction.

As the exceſſive dryneſs of the country renders ſprings very rare, the Koraquas would be unable to inhabit it, had they not found the means of remedying this ſcarcity of water. For this purpoſe they dig in the earth a kind of ciſterns or rather wells, to which they deſcend gradually by ſteps; and theſe people are the only African nation among whom our author ever found the ſame mark of induſtry.

As their wells always contain little water, and as none is to be loſt, they take care to ſecure it even from the birds, by cloſing up the mouth of the hole with ſtones and the branches of trees; ſo that, unleſs one knows the ſpot, it is impoſſible to find it. They go down into it every day, to fetch up as much water as may be neceſſary for the conſumption of their people and cattle. They draw it in a kind of veſſels made of hollowed wood, and pour it into the ſkins of buffaloes or giraffes, placed in a concave form on the ground to hold it; but they diſtribute it with the utmoſt parſimony, and never draw more than they abſolutely have occaſion for.

Notwithſtanding this ſtrict economy, the wells often become dry; and in that caſe the horde is obliged to remove to ſome other place. Among all the weſtern tribes, therefore, there are none who lead ſo wandering a life as the Koraquas: the conſequence of which is, that, as they often change their abode, and acquire new neighbours, they muſt, in ſome meaſure, adopt the cuſtoms of the nations near which they fix their reſidence. Some tribes of them greaſe themſelves like the Hottentots; while others tattoo their face, breaſt, and arms, after the manner of the Caffres. It is, however, to be remarked, that the ſame colour is not employed by all the Koraquas; each has his own, according as caprice may direct him in his choice, and it generally varies every day; which renders, as one may ſay, the inhabitants of the ſame horde ſtrangers to each other, and gives them a motley appearance, as if they were dreſſed for a maſquerade.

Kriſhna.

KRISHNA or Crisna, is an eaſtern river of conſiderable magnitude, which is very little known in Europe. We have the following account of it, and its tributary waters, and the countries through which it flows, in Mr Pennant's View of Hinduſtan:

"From Gangapatam, on the northern mouth of the Pennar, the land runs due north as far as Mottapilli, when it forms a ſtrong curve toward the eaſt; the point of which is one ſide of the great river Criſna, in about lat. 15° 43′. Its Delta, which winds round as far as Maſulipatam, is not conſiderable. This river annually overflows a vaſt tract of country, like the Indus on the weſtern ſide of this empire, and like all the other great rivers on this extenſive coaſt. The Criſna riſes from the foot of the weſtern Ghauts, and not more than 45 miles from Severndrug, on the weſtern coaſt. There is another branch to the eaſt, that riſes ſtill more northerly. On that ſide is Sattara, a ſtrong fortreſs, the capital of the Mahratta ſtate in the time of the rajahs of Sivaji's race. It was taken by him in 1673, and found to be the depoſitory of immenſe treaſure; at that time it belonged to the king of Vijapur: it was afterwards uſed by the Mahrattas as the lodgment of their riches, and alſo as a retreat for the more defenceleſs inhabitants of Puna, and other open towns, in time of potent invaſions.

"The river continues deſcending to the eaſt. In latitude 17° is Meritch, a ſtrong fortreſs, with a Jaghirdar territory, conquered from its owner by Hyder. In lat. 16° 45′, a ſmall river diſcharges itſelf into the Criſna from the north. It would not be worth mentioning, but that Panaela, a fortreſs of vaſt ſtrength, was made by Sumbaji, the profligate ſon of Sivaji, his reſidence juſt before his ſurpriſal in 1689, betrayed by Cablis Khan, the vile inſtrument of his pleaſures, corrupted by Aurengzebe. His extravagant love of women brought on him ruin. Informed by Cablis that a Hindu of rank and great beauty was on the road to be delivered by her parents to her huſband, according to the cuſtom of the Hindus, he inſtantly put himſelf at the head of a ſmall body of horſe to carry off the prize, and ordered Cablis to follow at a diſtance for his protection, in caſe of accidents in that hoſtile time. The traitor had given notice to Aurengzebe of this expedition, who, ſending a body of cavalry, ſurpriſed Sumbuji juſt as he had diſperſed the nuptial proceſſion.

"Into the north ſide of the Criſna, in lat. 16° 20′, falls the great river Bima, after a courſe of 350 miles. It riſes at the head of the weſtern Ghauts, parallel to Chaul in the Concan, and not above 50 miles from the ſea. It deſcends rapidly towards the ſouth-eaſt. In lat. 17° 40′ it receives a ſmall river from the weſt, on the ſouthern banks of which ſtands Vijapur, the capital of the famous kingdom of the ſame name, now poſſeſſed by the Mahrattas, but once governed by its own monarchs, till conquered by Aurengzebe in 1686. It was of great extent, and reached to the weſtern ſea, where it poſſeſſed the ports of Dabul, Vingorla, and Carapatan.

"The capital Vijapur is ſome leagues in circuit, ſeated in a fine but naked country, well watered. It makes a ſingular appearance from an adjacent eminence, filled with numbers of ſmall domes, and one of a majeſtic ſize. It was once a city of great ſplendour, and filled with palaces; moſques, mauſoleums, and public and private buildings of great magnificence; many of them are fallen to ruin, and give melancholy proofs of its former ſplendour. I ſhall not attempt to detail them. The palaces of the kings, and accommodations for their attendants, were within a vaſt fort, ſurrounded with a ditch 100 yards wide; the depth appeared to be great, but is now filled with rubbiſh: within the fort is the citadel. Tavernier ſays, that the great ditch was filled with crocodiles, by way of garriſon, to prevent all acceſs by water. Lieutenant Moor has his doubts about this, imagining that there never was any water in this foſs. That ſuch garriſons have exiſted I doubt not. I have read in Purchas, that in Pegu the foſſes of fortified places were ſtocked with thoſe tremendous animals, not only to keep out enemies, but to prevent deſertion This practice has certainly been of great antiquity in ſome parts of India: Pliny mentions it as uſed in a fair city of the Horatæ, a people I cannot trace.

“ The Criſna, above and below its conflux with the Bima, is fordable; and a few miles below its channel is 600 yards wide, made horrid with the number and rudeneſs of the variouſly formed rocks, which are never covered but in the rainy ſeaſon.

“ The Tungbuddra is another vaſt branch of the Criſna. It falls into it in lat. 16° 25′, and originates extremely ſouth, from a doubtful fountain. Towards its lower part it divides into three or four ſmall branches, which riſe remote from each other; the moſt ſouthern is the Curga Naïr's country; the moſt northern from the head of the Ghauts oppoſite to Onor, and ſcarcely 20 miles from the ſea. What muſt give this river great celebrity, is its having had on its banks, in lat. 15° 22′, the ſplendid city of Vijanagar. Feriſhta ſays, that it was founded in 1344 by Belaldeo king of the Carnatic, which in thoſe days included the whole peninſula. It was viſited by Cæſar Frederick a Venetian traveller, in 1565, and found deſerted and ruinous, having been ſacked by four confederated Mahomedan princes two years before, on which its monarch had retired to Penuconda. Frederick ſays that its circumference was 24 miles. Mr Rennel has given us a view of its preſent ſtate from Lieutenant Emitt, who viſited it in 1792.

“ The ruins of Vijanagar are in the little Sircar of Anagundi, which does not extend above 20 miles around this vaſt city. It is very ſingular, that that little Sircar is now poſſeſſed by a lineal deſcendant of Rama Rajah, the laſt great monarch of Vijanagar, and its attendant nations Canarine and Malabar, united 700 years before under the rule of Criſna Deva. Tippu wiſhed to reſerve this little tract to himſelf, for the ſatisfaction of generouſly reſtoring to the deſcendant the ſmall relique of the great empire of his anceſtors. He is denied the title of Rajah, inſtead of which he has the diminutive Raïl beſtowed on him. This is ſuitable to his revenues, which do not exceed two lacs of rupees, or 25,000 *per annum*, with the empty regality of a mint at Anagundi.” In the remainder of its courſe the Criſna offers nothing remarkable.

KUARA, is a beautiful tree, which grows in the ſouth and ſouth-weſt parts of Abyſſinia. With the ebony it is almoſt the only wood of the province of Kuara, of which it bears the name; but Mr Bruce aſſures us, that it is very frequent in all the countries where there is gold. “ It is (ſays he) what naturaliſts call *a Corallodendron*, probably from the colour of its flowers or of its fruit, both equal in colour to coral. Its fruit is a red bean, with a black ſpot in the middle of it, which is incloſed in a round capſula or covering, of a woody nature, very tough and hard. This bean ſeems to have been in the earlieſt ages uſed for a weight of gold among the Shangalla, and, where that metal is found, all over Africa; and by repeated experiments, I have found that, from the time of its being gathered, it varies very little in weight, and may perhaps have been the very beſt choice that therefore could have been made between the collectors and buyers of gold.

“ I have ſaid this tree is called kuara, which ſignifies the ſun. The bean is called *carat*, from which is derived the manner of eſteeming gold as ſo many carats fine. From the gold country in Africa it paſſed to India, and there came to be the weight of precious ſtones, eſpecially diamonds; ſo that to this day in India we hear it commonly ſpoken of gold or diamonds, that they are of ſo many carats fine or weight. I have ſeen theſe beans likewiſe from the Weſt-Indian iſlands. They are juſt the ſame ſize, but, as far as I know, are not yet applied to any uſe there.”

This is a very different account of the origin of the term CARAT from what we have given in the *Encyclopædia*; but the reader will judge for himſelf between the two.

KUMI, the name of an iſland between Japan and China, of which Perouſe writes in the following terms: “ On the 5th of May, at one o'clock in the morning, we made an iſland, which bore north north eaſt of us; we paſſed the reſt of the night, ſtanding off and on, under an eaſy ſail, and at day-break I ſhaped my courſe ſo as to run along the weſt coaſt of this iſland, at the diſtance of half a league. We ſounded ſeveral times without finding bottom. We were ſoon ſatisfied that this iſland was inhabited, for we ſaw fires in ſeveral places, and herds of oxen grazing on the ſea-ſhore. When we had doubled its weſt point, which is the moſt beautiful and beſt inhabited ſide, ſeveral canoes put off from the ſhore in order to obſerve us. They ſeemed to be extremely in fear of us; their curioſity cauſed them to advance within muſket ſhot, and their diſtruſt made them immediately flee away with ſpeed. Our ſhouts, geſtures, ſigns of peace, and the ſight of ſome ſtuffs, at length determined two of the canoes to come alongſide of us. I made each of them a preſent of a piece of nankeen and ſome medals. It was evident that theſe iſlanders had not left the coaſt with any intention of trafficking with us, for they had nothing to offer in exchange for our preſents; they only faſtened to a rope a bucket of freſh water, making ſigns to us, that they ſtill thought themſelves in our debt, but that they were going aſhore to fetch proviſion, which they expreſſed by putting their hand into their mouth. Before coming alongſide the frigate, they placed their hands upon their breaſt, and raiſed their arms towards the ſky: theſe geſtures were repeated by us, and then they reſolved to come on board; but it was with a want of confidence, which was ſtrongly expreſſed in their countenance during the whole time. They nevertheleſs invited us to approach the land, giving us to underſtand, that we ſhould there want for nothing. Theſe iſlanders are

Kumi, Kuriles.

are neither Japaneſe nor Chineſe, but, ſituate between theſe two empires, they ſeem to partake of both people. Their covering was a ſhirt and a pair of cotton drawers. Their hair, tucked up on the crown of the head, was rolled round a needle, which ſeemed to us to be gold: each of them had a dagger, the handle of which was gold alſo. Their canoes were made out of hollowed trees, and they managed them very indifferently. I could have wiſhed to land upon this iſland, but as we had brought the ſhip to, in order to wait for theſe canoes, and as the current ſet to the northward with extreme rapidity, we had drifted a great way to leeward, and our efforts to reach it would perhaps have been in vain: beſides, we had not a moment to loſe, and it was of the higheſt importance to us to get out of the Japan ſeas before the month of June; a period of ſtorms and hurricanes, which render theſe ſeas the moſt dangerous in the whole world.

"It is clear, that veſſels which might be in want would readily provide themſelves with proviſion, wood, and water, in this iſland, and perhaps even carry on a little trade; but as it is not more than three or four leagues in circumference, there is no great probability that its population exceeds four or five hundred perſons; and a few gold needles are not of themſelves a proof of wealth." Our author, by obſervation, found the latitude of Kumi to be 24° 33′ north; its longitude 120° 56′ eaſt from Paris.

KURILES, are a cluſter of iſlands, of which ſome account has been given under the word Kuril, in the *Encyclopædia.* In addition to that article, the following particulars are worthy of notice: Of the 21 iſlands belonging to Ruſſia, which are diſtinguiſhed from each other, not by names, but by numbers, four only are inhabited, viz. thoſe which are called the firſt, the ſecond, the thirteenth, and the fourteenth. The laſt two may indeed be counted only as one, becauſe the inhabitants all paſs the winter upon N° 14, and return to N° 13 to paſs the ſummer months. The others are entirely uninhabited, the iſlanders only landing there occaſionally from their canoes for the ſake of hunting foxes and otters. Several of theſe laſt mentioned iſlands are no better than large rocks, and there is not a tree on any one of them. The currents are very violent between the iſlands, particularly at the entrance of the channels, ſeveral of which are blocked up by rocks on a level with the ſea. The population of the four inhabited iſlands amounts at moſt to 1400 ſouls. The inhabitants are very hairy, wear long beards, and live entirely upon ſeals, fiſh, and the produce of the chace. When viſited by M. Perouſe, they had juſt been exempted for ten years from the tribute uſually paid to Ruſſia, becauſe the number of otters on their iſlands is very much diminiſhed. Theſe poor people are good, hoſpitable, and docile, and have all embraced the Chriſtian religion. The more ſouthern and independant iſlanders ſometimes paſs in canoes the channels that ſeparate them from the Ruſſian Kuriles, in order to give ſome of the commodities of Japan in exchange for peltries.

L.

Labdaſſeba, Laboratory.

LABDASSEBA, a tribe of ſavage Arabs who inhabit the deſart of Sahara in Africa. They are the moſt powerful of all thoſe tribes except the Ouadelims; and they reſemble theſe ſo much in every thing, that we ſhall give an account of the manners of both under the title Ouadelims, and of their country under that of Sahara.

LABORATORY, is an apparatus ſo neceſſary to the chemiſt, that every contrivance to render it more convenient, or to leſſen the expence of it, muſt contribute greatly to the advancement of ſcience. The abilities of *Morveau* alias *Guyton*, and the ſucceſs with which he has proſecuted the ſtudy of chemiſtry, are well known; and therefore his different methods of ſaving time and expence in making chemical experiments muſt be worthy of the notice of younger chemiſts.

In the ſecond volume of the Memoirs of the Ancient Academy of Dijon, we have a deſcription by him of a box containing a kind of portable laboratory, compoſed of a lamp with three wicks, diſpoſed in the figure of an equilateral triangle, to form an internal current of air, with ſupports for the different veſſels of digeſtion, diſtillation, evaporation, &c. He made a ſolution of ſilver with common aqua fortis and the metal in an alloyed ſtate, which anſwered very well as a re-agent, without having occaſion for any other utenſils but this box and apothecary's phials, which are every where to be found.

This apparatus, however, was confined in its application, and he ſoon thought of improving it. He conſtructed a lamp, on the principles of Argand, with three concentric circular wicks, each having an interior and exterior current of air. The effect ſurpaſſed his expectations with regard to the intenſity of the heat; but it was difficult to prevent the deſtruction of the hard ſolder round the wicks; and the glaſs retorts were frequently melted at the bottom, and diſfigured. It was attended with other inconveniences, and the quantity of oil conſumed was great.

A ſhort time afterwards, it occurred him to ſubſtitute, inſtead of the glaſs chimney of Argand's lamp, a cylinder of copper with an indented part or ledge a few millimetres (ſee Revolution, *Encycl.* n° 183.) above the flame, to perform the office of the indented chimney of glaſs, and by that means to render it practicable to raiſe the wick to a certain height without ſmoaking. This cylinder has three branches like a chaffing-diſh. By this apparatus two or three decilitres of water (about half an Engliſh wine pint) may be brought to boil in a copper or glaſs veſſel in about ſix or ſeven minutes. It has ſerved for a number of operations; but it was not till after he had obſerved the degree of heat obtained from the lamp in its ordinary ſtate, and particularly ſince he had ſubſtituted inſtead of the metallic tube a chimney of glaſs cut off at the length of three centimetres (rather more than one Engliſh inch) above the contraction, that he perceived all the advantages it was capable of affording; and that by means of a moveable ſupport for the reception of the different veſſels, which may be fixed at pleaſure by a thumb-ſcrew, this lamp furnace, at the ſame time that it gives light, and conſequently without any additional expence, may with facility be uſed for almoſt every one of the operations of chemiſtry; ſuch as digeſtions, ſolutions, cryſtallizations, concentrations; the rectification of acids; diſtillations on the ſand-bath, or by the naked fire; incinerations of the moſt refractory reſidues; analyſes with the pneumatic apparatus, or of minerals by the ſaline fuſion, &c. "I have not (ſays he) hitherto met with any exception but for complete vitrifications and cupellations; for even the diſtillations to dryneſs may be performed with ſome precautions, ſuch as that of transferring the matter into a ſmall retort blown by the enameller's lamp, and placing its bottom on a little ſand-bath in a thin metallic diſh." The ſupport here mentioned is ſimply a copper ring eight centimetres (3,15 inch.) in diameter, which is raiſed or lowered by ſliding on a ſtem of the ſame metal. Nothing more was required but to adapt it to the ſquare iron ſtem which paſſes through the reſervoir of the lamp. The connection is made by a piece of wood, in order that leſs of the heat might be diſperſed. As the lamp itſelf is capable of being moved on its ſtem, it is eaſy to bring it nearer or remove it at pleaſure from the veſſels, which remain fixed; a circumſtance which, independent of the elevation or depreſſion of the wick, affords the means of heating the retorts by degrees, of moderating or ſuppreſſing the fire inſtantly, or of maintaining it for ſeveral hours at a conſtant or determinate intenſity, from the almoſt inſenſible evaporation of cryſtallizable ſolutions to the ebullition of acids; properties never poſſeſſed by the athanor, of which chemiſts have boaſted ſo much. The advantage of theſe will be properly valued by thoſe operators who know that the moſt experienced and the moſt attentive chemiſts meet with frequent accidents, by which both their veſſels and the products of their operations are loſt for want of power in the management of the fire."

For the analyſis of ſtones, ſuch as the cryſtals of tin, the ſhortened chimney of glaſs is to be uſed; and the proceſs is to be begun by placing the mixture in a capſule of platina or ſilver 2$\frac{1}{4}$ inches in diameter. This capſule is to be placed on the ſupport, and the heat regulated in ſuch a manner, that ebullition ſhall take place without throwing any portion of the matter out of the veſſel. As ſoon as its contents are perfectly dry, they are to be transferred into a very thin crucible of platina, of which the weight is about 252$\frac{1}{2}$ grains Engliſh, and its diameter one inch and three-fourths. This crucible reſts on a ſmall ſupport of iron-wire, which ſerves to contract the ring; and the wick being at its greateſt elevation, with the ring lowered to the diſtance of 9$\frac{1}{2}$ inches from the upper rim of the chimney, Guyton produced, in leſs than twenty minutes, the ſaline fuſion to ſuch a degree, that from the commencement of the operation the decompoſition proceeded as far as to 0.70 of the mineral. The ſame apparatus, that is to ſay, with the ſhortened chimney, ſerves for oxidations, incinerations, torrefactions, and diſtillations to dryneſs.

In ſuch operations as require a leſs heat, he leaves the lamp with its large chimney abſolutely in the ſame ſtate as when it is uſed for illumination; and by raiſing and lowering either the ring which ſupports the veſſel, or the body of the lamp if the veſſels be fixed in communication with others, he graduates the heat at pleaſure. Vinegar diſtils without interruption at 2$\frac{1}{4}$ inches Engliſh from the upper termination of the chimney, that is to ſay, 7$\frac{1}{4}$ inches Engliſh from the flame. Water is made to boil in eight minutes, at the ſame height, in a glaſs veſſel containing one wine pint Engliſh, and is uniformly maintained at the diſtance of 8$\frac{3}{4}$ inches from the flame.

"I muſt not in this place (ſays our author) omit to mention a ſlight obſervation which this proceſs has afforded, becauſe it may lead to uſeful applications, and tends to point out one great advantage of this method of operating; namely, that an infinity of circumſtances may be perceived, which might not even be ſuſpected when the whole proceſs is carried on within a furnace. I have remarked, as did likewiſe ſeveral of my colleagues who were then preſent, that a column of bubbles conſtantly roſe from a fixed point of the retort on one ſide of the bottom. We were of opinion, that ſome particle of matter was in that place incorporated with the glaſs, which had a different capacity for heat from that of the reſt of the glaſs. In order to verify this conjecture, I endeavoured the following day to diſtil the ſame quantity of the ſame water in the ſame retort, after having introduced a button of cupelled ſilver, weighing nine decigrammes (20$\frac{1}{4}$ grains). At the commencement of the operation there was a ſmall ſtream of bubbles from the ſame point as before; but a ſhort time afterwards, and during the whole remaining time of operating, the largeſt and moſt inceſſant ſtream of bubbles roſe from the circumference of the button, which was often diſplaced by the motion; and in proportion to the time the product of the diſtillation was ſenſibly greater. Whence we may conclude, that metallic wires or rods, diſtributed through a maſs of water required to be kept in a ſtate of ebullition, and placed a little below its ſurface, would produce, without any greater expence of fuel, nearly the ſame effect as thoſe cylinders filled with ignited matter which are made to paſs through the boilers."

We have related this fact in Guyton's own words, or at leaſt in a faithful tranſlation of them; and we are far from calling it in queſtion, for it is a fact which has been often obſerved; but we think his inference from it too haſtily drawn. It is not conceivable that heat can be more rapidly conveyed through a maſs of liquid by the conducting power of metal, than by a free circulation; but we agree with what ſeems to be Mr Nicholſon's opinion *, that the thin ſtratum of water beneath the button becomes more ſuddenly and violently elaſtic than elſewhere, and therefore riſes regularly to the ſurface. The whole of this phenomenon the reader will find explained in our article STEAM (*Encycl.*), n° 10. But this is a digreſſion.

We return therefore to Guyton's laboratory, of which the reader will form a diſtinct notion from plate XXXIII. where fig. 1. repreſents the whole apparatus ready mounted for diſtillation, with the tube of ſafety and a pneumatic receiver. A is the body or reſervoir of the uſual lamp of Argand, with its ſhade and glaſs chimney. The lamp may be raiſed or lowered at pleaſure by means of the thumb ſcrew B, and the wick riſes

* *Journal*, Auguſt 1798, note, page 212.

and falls by the motion of the ſmall toothed wheel placed over the waſte cup. This conſtruction is moſt convenient, becauſe it affords the facility of altering the poſition of the flame with regard to the veſſels, which remain fixed; and the troubleſome management of bended wires above the flame for the ſupport of the veſſels is avoided, at the ſame time that the flame itſelf can be brought nearer to the matter on which it is intended to act. D, a ſupport conſiſting of a round ſtem of braſs, formed of two pieces which ſcrew together at about two thirds of its height. Upon this the circular ring E, the arm F, and the nut G ſlide, and are fixable each by its reſpective thumb-ſcrew. The arm alſo carries a moveable piece H, which ſerves to ſuſpend the veſſels in a convenient ſituation, or to ſecure their poſition. The whole ſupport is attached to the ſquare iron ſtem of the lamp by a piece of hard wood I, which may be fixed at any required ſituation by its ſcrew. K repreſents a ſtand for the receivers. Its moveable tablet L is fixed at any required elevation by the wooden ſcrew M. The piece which forms the foot of this ſtand is fixed on the board N; but its relative poſition with regard to the lamp may be changed by ſliding the foot of the latter between the pieces OO. P, another ſtand for the pneumatic trough. It is raiſed or lowered, and fixed to its place, by a ſtrong wooden ſcrew, Q. R is a tube of ſafety, or reverſed ſyphon, which ſerves, in a great meaſure, to prevent the bad effects of having the veſſels either perfectly cloſed, or perfectly open. Suppoſe the upper bell-ſhaped veſſel to be nearly of the ſame magnitude as the bulb at the lower end of the tube, and that a quantity of water, or other ſuitable fluid, ſomewhat leſs than the contents of that veſſel, be poured into the apparatus: In this ſituation, if the elaſticity of the contents of the veſſels be leſs than that of the external air, the fluid will deſcend into the bulb, and atmoſpheric air will follow and paſs through the fluid into the veſſels: but, on the contrary, if the elaſticity of the contents be greater, the fluid will be either ſuſtained in the tube, or driven into the bell-ſhaped veſſel; and if the force be ſtrong enough, the gaſeous matter will paſs through the fluid, and in part eſcape.

Fig. 2. Shews the lamp furnace diſpoſed to produce the ſaline fuſion; the chimney of glaſs ſhortened; the ſupport D turned down; the capſule of platina or ſilver S placed on the ring very near the flame.

Fig. 3. The ſame part of the apparatus, in which, inſtead of the capſule, a very thin and ſmall crucible of platina T is ſubſtituted, and reſts upon a triangle of iron wire placed on the ring.

Fig 4. Exhibits the plan of this laſt diſpoſition.

LACERTA, in aſtronomy. See ASTRONOMY, n° 406. *Encycl.*

LACMUS, a dye ſtuff prepared by the Dutch from the LICHEN ROCELLA, which ſee in this *Supplement*.

LACSHA, the Indian name of the lac inſect, which has been deſcribed in the *Encyclopedia* under the title COCCUS, *Species* 5. Since that article was publiſhed, a deſcription of that inſect, which is more to be depended upon, has been given to the world in the ſecond volume of the Aſiatic Reſearches. It is by Mr Roxburgh, ſurgeon on the Madras eſtabliſhment, and was communicated to the Society by Dr James Anderſon phyſician at Fort St George, who obſerves, that Mr Roxburgh's diſcovery will bring the lacſha as a genus into the claſs *Hemiptera* of Linnæus.

“ Some pieces of very freſh-looking lac (ſays Mr Roxburgh) adhering to ſmall branches of mimoſa cinerea, were brought me from the mountains on the 20th of November 1789. I kept them carefully, and to-day, the 4th of December, fourteen days from the time they came from the hills, myriads of exceedingly minute animals were obſerved creeping about the lac and branches it adhered to, and more ſtill iſſuing from ſmall holes over the ſurface of the cells: other ſmall and perforated excreſcences were obſerved with a glaſs amongſt the perforations, from which the minute inſects iſſued, regularly two to each hole, and crowned with ſome very fine white hairs. When the hairs were rubbed off, two white ſpots appeared. The animals, when ſingle, ran about pretty briſkly, but in general they were ſo numerous as to be crowded over one another. The body is oblong, tapering moſt towards the tail, below plain, above convex, with a double, or flat margin: laterally on the back part of the thorax are two ſmall tubercles, which may be the eyes: the body behind the thorax is croſſed with twelve rings: legs ſix; feelers (antennæ) half the length of the body, jointed, hairy, each ending in two hairs as long as the antennæ: rump, a white point between two terminal hairs, which are as long as the body of the animal. The mouth I could not ſee. On opening the cells, the ſubſtance that they were formed of cannot be better deſcribed, with reſpect to appearance, than by ſaying it is like the tranſparent amber that beads are made of: the external covering of the cells may be about half a line thick, is remarkably ſtrong, and able to reſiſt injuries: the partitions are much thinner: the cells are in general irregular ſquares, pentagons and hexagons, about an eighth of an inch in diameter, and one quarter deep: they have no communication with each other. All thoſe I opened during the time the animals were iſſuing, contained in one half, a ſmall bag filled with a thick red jelly-like liquor, replete with what I take to be eggs: theſe bags, or utriculi, adhere to the bottom of the cells, and have each two necks, which paſs through perforations in the external coat of the cells, forming the fore-mentioned excreſcences, and ending in ſome very fine hairs. The other half of the cells have a diſtinct opening, and contain a white ſubſtance, like ſome few filaments of cotton rolled together, and numbers of the inſects themſelves ready to make their exit. Several of the ſame inſects I obſerved to have drawn up their legs, and to lie flat: they did not move on being touched, nor did they ſhew any ſigns of life with the greateſt irritation.

“ *December* 5. The ſame minute hexapedes continue iſſuing from their cells in numbers: they are more lively, of a deepened red colour, and fewer of the motionleſs ſort. To-day I ſaw the mouth: it is a flattened point about the middle of the breaſt, which the little animal projects on being compreſſed.

“ *December* 6. The male inſects I have found to-day: a few of them are conſtantly running among the females moſt actively: as yet they are ſcarce more, I imagine, than one to 5000 females, but twice their ſize. The head is obtuſe; eyes black, very large; antennæ clavated, feathered, about ⅔ds the length of the body: below the middle an articulation, ſuch as thoſe in the legs: colour between the eyes a beautiful ſhining green: neck very ſhort: body oval, brown: abdomen oblong, the length of body and head: legs ſix: wings membranaceous, four, longer than the body, fixed to the ſides of the thorax, narrow at their inſertions, growing broader for $\frac{2}{3}$ds of their length, then rounded; the anterior pair is twice the ſize of the poſterior: a ſtrong fibre runs along their anterior margins: they lie flat, like the wings of a common fly when it walks or reſts: no hairs from the rump: it ſprings moſt actively to a conſiderable diſtance on being touched: mouth in the under part of the head: maxillæ tranſverſe. To-day the female inſects continue iſſuing in great numbers, and move about as on the 4th.

"*December* 7. The ſmall red inſects ſtill more numerous, and move about as before: winged inſects, ſtill very few, continue active. There have been freſh leaves and bits of the branches of both *Mimoſa Cinerea* and *Corinda* put into the wide mouthed bottle with them: they walk over them indifferently, without ſhewing any preference, or inclination to work or copulate. I opened a cell whence I thought the winged flies had come, and found ſeveral, eight or ten, more in it, ſtruggling to ſhake off their incumbrances: they were in one of thoſe utriculi mentioned on the 4th, which ends in two mouths, ſhut up with fine white hairs, but one of them was open for the exit of the flies; the other would no doubt have opened in due time: this utriculus I found now perfectly dry, and divided into cells by exceeding thin partitions. I imagine, before any of the flies made their eſcape, it might have contained about twenty. In theſe minute cells with the living flies, or whence they had made their eſcape, were ſmall dry dark-coloured compreſſed grains, which may be the dried excrements of the flies."

LAMANON (Robert Paul), of the academy at Turin, correſpondent of the Academy of Sciences at Paris, and member of the Muſeum in the ſame city, was born at Salon in Provence, in 1752, of an old and reſpectable family. Being a younger ſon, he was deſtined for the church, and ſent to Paris to complete his theological ſtudies; but getting acquainted with the philoſophers (as they called themſelves), he ſoon loſt all reliſh for the ſtudy of theology, and devoted himſelf to the phyſical ſciences, eſpecially thoſe of chemiſtry and mineralogy. Into the church, however, he got, and roſe to the dignity of canon; but by the death of his father and elder brother, having acquired the right of directing his own future exertions, he haſtened to quit a profeſſion, towards which he felt no partiality.

A prelate, then in high favour at court, hearing of Lamanon's intention of quitting his office of canon, offered him a conſiderable ſum, to induce him to reſign in favour of one of his dependents. The chapter of Arles, replied our young eccleſiaſtic, did not ſell me my benefice, I ſhall therefore reſtore it in the ſame manner that I received it. This conduct was certainly meritorious; and his eulogiſt *Ponce* mentions another trait of his character, which ſets him in a very amiable point of view; he refuſed to accept of his paternal inheritance, otherwiſe than as an equal ſharer with his brothers and ſiſters.

Thus liberated from the trammels of his former profeſſion, Lamanon applied himſelf with uncommon ardour to ſtudy. Eager to raiſe the awful veil that conceals from our eyes the ſecrets of nature; perſuaded, that even the greateſt genius only amuſes itſelf with falſe ſyſtems in the ſilence of a cabinet; convinced of the neceſſity of much and various obſervation, and of ſurpriſing Nature, as it were, in the very fact, in order to penetrate into the ſublimity of her operations;—our young philoſopher travelled through Provence and Dauphine, and ſcaled the Alps and Pyrenees. At the ſight of theſe vaſt natural laboratories the bent of his mind burſt forth inſtantaneouſly; he climbed to the ſummit of rocks, and explored the abyſs of caverns, weighed the air, analyſed ſpecimens, and, in his ardent fancy, having attained the ſecrets of creation, he formed a new ſyſtem of the world. On his return home, he applied with additional intereſt to the ſtudy of meteorology, mineralogy, natural philoſophy, and the other branches of the hiſtory of nature.

Whilſt he was meditating a viſit to Paris for the purpoſe, as his eulogiſt expreſſes himſelf, of converſing with the luminaries of ſcience, the inhabitants of the commune of Salon, having loſt a cauſe againſt their lord, unanimouſly elected Lamanon, with whoſe integrity and abilities they were well acquainted, to go and ſolicit of the council the repeal of an unjuſt decree that had been obtained by partiality. The reply of the young philoſopher on this occaſion is an additional proof of his uncommon diſintereſtedneſs. "As I intend (ſaid he) to go to Paris on buſineſs of my own, I cannot think of accepting your offer of 24 livres daily pay: a twelfth of this ſum will cover the extraordinary expences of the journeys that I ſhall be obliged to make to Verſailles on your account." He had the ſatisfaction of complete ſucceſs in the buſineſs thus undertaken.

Having ſatisfied his curioſity in Paris, he went over to England. During the paſſage, though much incommoded by ſea-ſickneſs, and in imminent hazard of being overwhelmed by the tumbling waves of a very ſtormy ſea, he cauſed himſelf to be tied to the main-maſt, in order to contemplate at leiſure ſo grand and fearful a ſpectacle. The burſts of thunder, the howling of the wind, the brilliancy of the lightning, the glancing of the ſpray which covered him every moment, theſe objects, ſo terrible to an ordinary man, threw him into a kind of mental intoxication, and he has often declared, that this day was the moſt exquiſite of his whole life.

Convinced that the friendſhip of an eminent man elevates the ſoul, excites generous emulation, and becomes an additional ſtimulus to one whoſe delight is ſtudy, and whoſe moſt preſſing want is an object on which to place his affection, Lamanon anxiouſly endeavoured to merit the regard of Condorcet, ſo well known by his talents, his impieties, his rebellion, and his misfortunes. This academician, juſtly conſidering that an apoſtate prieſt would be ready to join the conſpiracy of the philoſophiſts againſt the altar and the throne, received Lamanon with diſtinction, and at length admitted him to his moſt intimate friendſhip.

During the three ſucceſſive years that Lamanon ſpent at Paris, he followed with care the track of thoſe learned ſocieties, of which he had been elected a member. He became at this period, together with Count de Gebelin, and ſome other philoſophers and artiſts, one of the founders of the Muſeum, the greater part of the members of which are now reunited in the open ſociety of ſciences, letters, and arts, at Paris. Among the different papers of his that were read at various meetings of theſe ſocieties, Ponce mentions with particular approbation what he calls *a notice* of Adam de Craponc, an eminent hydraulic engineer; a memoir on the Cretins; a memoir on the theory of the winds; a treatiſe on the alteration in the courſe of rivers, particularly the Rhone; and another on an enormous bone belonging to ſome cetaceous fiſh, that was dug up at Paris in laying the foundations of a houſe in the *rue Dauphine*. We have not ſeen theſe memoirs; but as their author was the friend of Condorcet, and fancied that he had attained the ſecrets of creation, we can eaſily conceive their tendency.

Having reſolved again to reviſit Switzerland and Italy, Lamanon firſt went to Turin, where he allied himſelf to the learned of that country. During his ſtay there, the brilliant novelty diſcovered by Montgolfier was occupying the attention of all the philoſophers of Europe. Lamanon, deſirous of making ſome experiments of this kind himſelf, aſcended in a balloon from the city of Turin; but not perceiving in this diſcovery, which had at firſt highly intereſted him, an object of public utility; not foreſeeing, that one day, on the plains of Fleurus, it would be the cauſe of rallying and eſtabliſhing victory under the ſtandards of France, he returned to his favourite occupations. Purſuing his route from Piedmont, he viſited Italy, and returned by Switzerland, where he explored the Alps and aſcended the ſummit of Mont Blanc: thence returning, loaden with the ſpoils of the countries which he had traverſed, to Provence, he employed himſelf in the arrangement of the intereſting fruits of his journey.

Of the ſcrupulous exactneſs of his obſervations, his eulogiſt gives the following inſtance: "Being convinced that the plain of Crau, divided by the channel of the Durance, had formerly been a lake, he wiſhed to be abſolutely aſſured of it. For this purpoſe he collected a ſpecimen of each of the ſtones that are to be found in this vaſt plain; the number of theſe he found to amount to nineteen; then tracing the courſe of the river towards its head, near the frontiers of Savoy, he obſerved, that above each junction of the tributary ſtreams with the Durance, the variety of pebbles diminiſhed. Afterwards aſcending the current of each of theſe ſmaller ſtreams, he diſcovered on their banks the original rock of every pebble that overſpreads the plain of Crau; thus inconteſtably proving, that this plain was anciently a lake formed by the waters of the Durance, and the ſtreams that fall into it. If all philoſophers (ſays our author) would conduct their examinations with equal preciſion, certain hypotheſes, more brilliant than ſolid, would not find ſo many admirers; the charm of imagination, and the graces of ſtyle, would not ſo often encroach upon the impreſcriptible rights of nature and truth."

To citizen Ponce this appears a demonſtration of Lamanon's theory; but we cannot ſay that it does ſo to us. It may be a kind of proof, though not a demonſtration, that in ſome convulſion of nature, ſtones had been rolled from the rock, and the plain of Crau, for a time, overflowed by the Durance; but it ſurely furniſhes no evidence of that plain's having ever been *a permanent lake*. It *may* have been ſo; but ſuch inveſtigations as this will not guard philoſophers againſt the deluſions of favourite hypotheſes.

It was at the time when Lamanon was preparing for the preſs his great work on the *Theory of the Earth*, that the French government conceived the vaſt project of completing the diſcoveries of Captain Cook: the academy of ſciences was entruſted with the care of ſelecting men capable of rectifying our notions of the ſouthern hemiſphere, of improving hydrography, and advancing the progreſs of natural hiſtory. Condorcet, not knowing any one better qualified for this laſt department than Lamanon, wrote to him an invitation to ſhare the danger and glory of this great enterprize. He accepted with eager tranſport a propoſal that fulfilled his higheſt expectations, haſtened to Paris, refuſed in a conference with the miniſter the ſalary that was offered, took a haſty leave of his friends, and departed for Breſt.

On the 1ſt of Auguſt 1785, the armament ſet ſail under the orders of La Perouſe, an experienced commander, whoſe patriotiſm and ſcientific zeal were equal to his courage and good ſenſe, and who had already merited the public confidence. The philoſophers of all Europe were in expectation of thoſe uſeful diſcoveries, the probable fruit of the zeal and talents employed in the expedition. The beginning of the voyage was proſperous. After various delays, and a multitude of obſervations, the two veſſels arrived at the iſland of Maouna, one of the ſouthern Archipelago. The impatient Lamanon, eager to aſſure himſelf of the truth of the publiſhed accounts of that country, debarked with Langle, the ſecond in command. At the moment of their return, the natives, in hopes of booty, which had been excited by the number of preſents that they had received, ſeized upon the boats, and attacked the party. The French were obliged to have recourſe to arms for ſelf-defence, and a deſperate combat enſued. Lamanon, Langle, and ten of the two boats crews, fell a ſacrifice to the fury of theſe barbarians.

Thus periſhed Lamanon, a young man ardent in the purſuits of ſcience, to a high degree diſintereſted, and a zealot in what he thought the cauſe of liberty. He refuſed the ſalary which was allotted to him when he was appointed to this unfortunate expedition; for "if I do not feel ſatisfied (ſaid he) on board the veſſel; if my inclination or curioſity lead me to quit the ſhip,—I ſhould be unhappy if any power in the world had acquired the right of preventing me."

According to M. Ponce, Lamanon ſeemed born to bring about a revolution in ſcience: the depth of his ideas, the energy of his character, the ſagacity of his mind, united to that lively curioſity that can draw inſtruction out of any thing, and leaves nothing unexplored, would have led him to the moſt valuable diſcoveries. In perſon he was tall; and to great vivacity and expreſſion of feature added prodigious ſtrength and activity; in a word, Nature formed him with ſuch care, as if ſhe had intended him for one of thoſe few who are deſtined to great exploits. His ſtyle was nervous, often poetical, without loſing ſight of propriety, and the language of ſentiment might frequently be diſcovered in the midſt of ſtrong and ſtriking expreſſions; and if he wanted the exquiſitely dazzling poliſh of diction, he was eminently gifted with the preciſion of logical reaſoning, which commands attention and enforces perſuaſion.

LAMP (ſee *Encycl.*) is an inſtrument compriſing three articles which demand our attention, *viz.* the oil, the wick, and the ſupply of air. It is required that the oil ſhould be readily inflammable, without containing any fetid ſubſtance which may prove offenſive, or mucilage, or other matter, to obſtruct the channels of the wick. Mr Nicholſon ſays*, that he knows of no proceſs by which oils can be meliorated for this purpoſe, except that of waſhing with water containing acid or alkali. Either of theſe is ſaid to render the mucilage of animal oils more ſoluble in water; but acid is to be preferred, becauſe it is leſs diſpoſed to combine with the oil itſelf. Perhaps oil might be deprived of all fetid ſmell in burning, by being made to paſs through Collier's filtering apparatus, deſcribed under the word FILTER in this *Suppl.*

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* *Journal*, vol. i. n° 2.

The office of the wick appears to be chiefly, if not ſolely, to convey the oil by capillary attraction to the place of combuſtion. As the oil is conſumed and flies off, other oil ſucceeds, and in this way a continued current of oil and maintenance of the flame are effected. But as the wicks of lamps are commonly formed of combuſtible matter, it appears to be of ſome conſequence what the nature and ſtructure of this material may be. It is certain that the flame afforded by a wick of ruſh differs very conſiderably from that afforded by cotton; though perhaps this difference may, in a great meaſure, depend on the relative dimenſions of each. And if we may judge from the different odour in blowing out a candle of each ſort, there is ſome reaſon to ſuſpect that the decompoſition of the oil is not effected preciſely in the ſame manner in each. We have alſo ſome obſcure accounts of prepared wicks for lamps, which are ſtated to poſſeſs the property of facilitating the combuſtion of very impure oils, ſo that they ſhall burn for many hours without ſmoke or ſmell.

The economical wicks of M. Leger, concerning which a report was preſented to the Academy at Paris in 1782 by Condorcet, Lavoiſier, and De Milly, were compoſed of cotton of different ſizes and forms, namely, round and flat, according to the uſe they were intended to ſerve. They were covered with a fat ſubſtance, of a ſmell not diſagreeable, but feebly aromatic. From the trials of theſe commiſſaries it was aſcertained: 1. That they afforded a clearer flame, with leſs undulation. 2. That they conſumed ſomewhat leſs oil; and, 3. That they poſſeſſed the remarkable property of affording neither ſmell nor ſmoke, however common the oil made uſe of. When uſing a lamp with a flat wick, we have ourſelves found a piece of clean cotton ſtocking anſwer the purpoſe better than the cotton wicks which are ſold in the ſhops.

The acceſs of air is of the laſt importance in every proceſs of combuſtion. When a lamp is fitted up with a very ſlender wick, the flame is ſmall, and of a brilliant white colour: if the wick be larger, the combuſtion is leſs perfect, and the flame is brown: a ſtill larger wick not only exhibits a brown flame, but the lower internal part appears dark, and is occupied by a portion of volatiliſed matter, which does not become ignited until it has aſcended towards the point. When the wick is either very large or very long, part of this matter eſcapes combuſtion, and ſhews itſelf in the form of coal or ſmoke. The different intenſity of the ignition of flame, according to the greater or leſs ſupply of air, is remarkably ſeen by placing a lamp with a ſmall wick beneath a ſhade of glaſs not perfectly cloſed below, and more or leſs covered above. While the current of air through the glaſs ſhade is perfectly free, the flame is white; but in proportion as the aperture above is diminiſhed, the flame becomes brown, long, wavering, and ſmoky; it inſtantly recovers its original whiteneſs when the opening is again enlarged. The inconvenience of a thick wick has been long ſince obſerved, and attempts made to remove it; in ſome inſtances, by ſubſtituting a number of ſmall wicks inſtead of a larger; and in others, by making the wick flat inſtead of cylindrical. The moſt ſcientific improvement of this kind, though perhaps leſs ſimple than the ordinary purpoſes of life demand, is the well known lamp of Argand, deſcribed in the *Encyclopædia.*

Much has been ſaid of this lamp, and great praiſe laviſhed on the inventor. It cannot indeed be denied that it was a very pretty invention, nor have we the ſlighteſt wiſh to detract from the merit of M. Argand; but truth compels us to ſay, that the ſame thought had occurred to others as early as to him, and that lamps had been conſtructed on his principles long before he had publiſhed an account of his lamp to the world (A).

Many ingenious men have endeavoured to determine the moſt economical method of lighting up large halls and workhouſes by means of different lamps and candles; and when the expence of tallow and oil is conſidered, it will be admitted that they could not employ their time in a manner more beneficial to the poor and the induſtrious. Among others, Count Rumford and M. Haſſenfratz have turned their attention to this ſubject; and the reſults of their inveſtigations are worthy of notice. To the Count, a method occurred for meaſuring the relative quantities of light emitted by lamps of different conſtructions, which is at once ſimple and accurate. It is as follows:

Let the two burning lamps, or other lights to be compared, be called A and B; and let them be placed at equal heights upon two light tables, or moveable ſtands, in a darkened room; let a ſheet of clean white paper be equally ſpread out, and faſtened upon the wainſcot, or ſide of the room, at the ſame height from the floor as the lights; and let the lights be placed over-againſt this ſheet of paper, at the diſtance of ſix or eight feet from it, and ſix or eight feet from each other, in ſuch a manner, that a line drawn from the centre of the paper, perpendicular to its ſurface, ſhall biſect the angle formed by lines drawn from the lights to that centre; in which caſe, conſidering the ſheet of paper as a plane ſpeculum, the one light will be preciſely in the line of reflection of the other.

This may be eaſily performed, by actually laying a piece of a looking-glaſs, ſix or eight inches ſquare, flat upon the paper, in the middle of it; and obſerving, by means of it, the real lines of reflection of the lights from that plane, removing it afterwards, as ſoon as the lights are properly arranged. When this is done, a ſmall cylinder of wood, about $\frac{1}{4}$th of an inch in diameter, and ſix inches long, muſt be held in a vertical poſition, about two or three inches before the centre of the ſheet of paper, and in ſuch a manner, that the two ſhadows of the cylinder, correſponding to the two lights, may be diſtinctly ſeen upon the paper.

If theſe ſhadows ſhould be found to be of unequal denſities, which will almoſt always be the caſe, then that light whoſe correſponding ſhadow is the denſeſt muſt be removed farther off, or the other muſt be brought nearer to the paper, till the denſities of the ſhadows appear to be exactly equal; or, in other words, till the denſities of the rays from the two lights are equal *at the ſurface of the paper;* when, the diſtances of the lights from

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(A) One of theſe was employed in the college of Glaſgow, by the lecturer on chemiſtry, ſo long ago as 1766.

from the centre of the paper being meaſured, the ſquares of thoſe diſtances will be to each other as the real intenſities of the lights in queſtion at their ſources.

If, for example, the weaker light being placed at the diſtance of four feet from the centre of the paper, it ſhould be found neceſſary, in order that the ſhadows may be of the ſame denſity, to remove the ſtronger light to the diſtance of eight feet from that centre, in that caſe, the real intenſity of the ſtronger light will be to that of the weaker as 8^2 to 4^2; or as 64 to 16; or 4 to 1; and ſo for any other diſtances.

It is well known, that when any quality proceeds from a centre in ſtraight lines in all directions, like the light emitted by a luminous body, its intenſity at any given diſtance from that centre will be as the ſquare of that diſtance inverſely; and hence it is clear, that the intenſities of the lights in queſtion, at their ſources, muſt be to each other as the ſquares of their diſtances from that given point *where their rays uniting are found to be of equal denſity*. For, putting $x =$ the intenſity of B, if P repreſents the point where the rays from A and from B meeting are found to be of equal denſity or ſtrength, and if the diſtance of A from P be $= m$, and the diſtance of B from the ſame point P $= n$; then, as the intenſity of the light of A at P is $= \frac{x}{m^2}$, and the intenſity of the light of B at the ſame place $= \frac{y}{n^2}$, and as it is $\frac{x}{m^2} = \frac{y}{n^2}$ by the ſuppoſition, it will be $x : y :: m^2 : n^2$.

That the ſhadows being of equal denſity at any given point, the intenſities of the illuminating rays muſt of neceſſity be equal at that point alſo, is hence evident, that the total abſence of light being perfect blackneſs, and the ſhadow correſponding to one of the lights in queſtion being deeper or fainter, according as it is more or leſs enlightened by the other, when the ſhadows are equal, the intenſities of the illuminating rays muſt be equal likewiſe.

In removing the lights, in order to bring the ſhadows to be of the ſame denſity, care muſt be taken to recede from, or advance towards, the centre of the paper in a ſtraight line, ſo that the one light may always be found exactly in the line of reflection of the other; otherwiſe the rays from the different lights falling upon the paper, and conſequently upon the ſhadows, at different angles, will render the experiment fallacious.

When the intenſity of one ſtrong light is compared with the intenſities of ſeveral ſmaller lights taken together, the ſmaller lights ſhould be placed in a line perpendicular to a line drawn to the centre of the paper, and as near to each other as poſſible; and it is likewiſe neceſſary to place them at a greater diſtance from the paper than when only ſingle lights are compared.

In all caſes, it is abſolutely neceſſary to take the greateſt care that the lights compared be properly trimmed, and that they burn clear and equally, otherwiſe the reſults of the experiments will be extremely irregular and inconcluſive. It is aſtoniſhing what a difference there is in the quantities of light emitted by the ſame candle, when it burns with its greateſt brilliancy, and when it has grown dim for want of ſnuffing. But as this diminution of light is progreſſive, and as the eye inſenſibly conforms to the quantity of light actually preſent, it is not always taken notice of by the ſpectators; it is nevertheleſs very conſiderable, in fact, as will be apparent to any one who will take the trouble to make the experiment; and ſo great is the fluctuation in the quantity of light emitted by burning bodies, lamps, or candles, in all caſes, even under the moſt favourable circumſtances, that this is the ſource of the greateſt difficulties which our author met with in determining the relative intenſities of lights by the method here propoſed.

To aſcertain by this method the comparative denſities, or intenſities, of the light of the moon and of that of a candle, the moon's direct rays muſt be received upon a plane white ſurface, at an angle of incidence of about 60°, and the candle placed in the line of the reflection of the moon's rays from this ſurface; when the ſhadows of the cylinder, correſponding to the moon's light and to that of the candle, being brought to be of equal denſity, by removing the candle farther off, or bringing it nearer to the centre of the white plane, as the occaſion may require, the intenſity of the moon's light will be equal to that of the candle *at the given diſtance of the candle from the plane*.

To aſcertain the intenſity of the light of the heavens, by day or by night, this light muſt be let into a darkened room through a long tube blackened on the inſide, when its intenſity may be compared with that of a candle or lamp by the method above deſcribed.

The Count, however, has contrived an apparatus for aſcertaining the intenſity of the ſun's light, compared with the light emitted by any artificial illuminator, with much greater accuracy than it can be done by this ſimple method. That apparatus we ſhall deſcribe under the title PHOTOMETER in this *Supplement*; and in the mean time we proceed to lay before our readers the reſults of his experiments as they relate to economy in the production of artificial light.

1
Of the relative quantities of oil conſumed, and of light emitted, by an Argand's lamp, and by a lamp on the common conſtruction, with a riband wick.

The brilliancy of Argand's lamp is not only unrivalled, but the invention is in the higheſt degree ingenious, and the inſtrument uſeful for many purpoſes; but ſtill, to judge of its real merits as an illuminator, it was neceſſary to know whether it gives more light than another lamp *in proportion to the oil conſumed*. This point he determined in the following manner:

Having placed an Argand's lamp, well trimmed, and burning with its greateſt brilliancy, before his *photometer*, and over againſt it a very excellent common lamp, with a riband wick about an inch wide, and which burnt with a clear, bright flame, without the leaſt appearance of ſmoke, he found the intenſities of the light emitted by the two lamps to be to each other as 17956 to 9063; the denſities of the ſhadows being equal when, the Argand's being placed at the diſtance of 134 inches, the common lamp was placed at the diſtance of 95,2 inches, from the field of the photometer.

Both lamps having been very exactly weighed when they were lighted, they were now (without being removed from their places before the photometer) cauſed to burn with the ſame brilliancy juſt 30 minutes; they were then extinguiſhed and weighed again, and were found to have conſumed of oil, the Argand's lamp $\frac{253}{8192}$, and the common lamp $\frac{163}{8192}$, of a Bavarian pound.

Now, as the quantity of light produced by the Argand's gand's lamp, in this experiment, is to the quantity produced by the common lamp as 17956 to 9063, or as 187 to 100, while the quantity of oil conſumed by the former is to that conſumed by the latter only in the ratio of 253 to 163, or as 155 to 100, it is evident that the quantity of light produced by the combuſtion of a given quantity of oil in an Argand's lamp is greater than that produced by burning the ſame quantity in a common lamp, in the ratio of 187 to 155, or as 100 to 85.

The ſaving, therefore, of oil which ariſes from making uſe of an Argand's lamp inſtead of a common lamp, in the production of light, is evident; and it appears, from this experiment, that that ſaving cannot amount to leſs than fifteen *per cent.* How far the advantage of this ſaving may, under certain circumſtances, be counterbalanced by inconveniences that may attend the making uſe of this improved lamp, our author does not pretend to determine.

2
Of the relative quantities of light emitted by an Argand's lamp and by a common wax candle.

The Count made a conſiderable number of experiments to determine the relative quantities of light emitted by an Argand's lamp and a common wax candle; and the general reſult of them is, that a common Argand's lamp, burning with its uſual brightneſs, gives about as much light as nine good wax-candles; but the ſizes and qualities of candles are ſo various, and the light produced by the ſame candle ſo fluctuating, that it is very difficult to aſcertain, with any kind of preciſion, what a common wax-candle is, or how much light it ought to give. He once found that his Argand's lamp, when it was burning with its greateſt brilliancy, gave twelve times as much light as a good wax candle ¾ths of an inch in diameter, but never more.

3.
Of the fluctuations of the light emitted by candles.

To determine to what the ordinary variations in the quantity of light emitted by a common wax-candle might amount, he took ſuch a candle, and, lighting it, placed it before the photometer, and over againſt it an Argand's lamp, which was burning with a very ſteady flame; and meaſuring the intenſity of the light emitted by the candle from time to time, during an hour, the candle being occaſionally ſnuffed when it appeared to ſtand in need of it, its light was found to vary from 100 to about 60. The light of a wax-candle of an inferior quality was ſtill more unequal; but even this was but trifling, compared to the inequalities of the light of a tallow-candle.

An ordinary tallow-candle, of rather an inferior quality, having been juſt ſnuffed, and burning with its greateſt brilliancy, its light was as 100; in eleven minutes it was but 39; after eight minutes more had elapſed, its light was reduced to 23; and in ten minutes more, or twenty-nine minutes after it had been laſt ſnuffed, its light was reduced to 16. Upon being again ſnuffed, it recovered its original brilliancy, 100.

4
Of the relative quantities of bees-wax, tallow, olive-oil, rape-oil, and linſeed-oil, conſumed in the production of light.

In order to aſcertain the relative quantities of bees wax and of olive-oil conſumed, in the production of light, the Count proceeded in the following manner: Having provided an end of a wax-candle of the beſt quality, ,68 of an inch in diameter, and about four inches in length, and a lamp with five ſmall wicks, which he had found upon trial to give the ſame quantity of light as the candle, he weighed very exactly the candle and the lamp filled with oil, and then, placing them at equal diſtances (forty inches) before the field of the photometer, he lighted them both at the ſame time; and, after having cauſed them to burn with preciſely the ſame degree of brightneſs *juſt one complete hour*, he extinguiſhed them both, and, weighing them a ſecond time, he found that 100 parts of wax and 129 parts of oil had been conſumed.

Hence it appears, that the conſumption of bees wax is to the conſumption of olive-oil, in the production of the ſame given quantity of light, as 100 is to 129.

In this experiment no circumſtance was neglected that could tend to render the reſult of it concluſive; care was taken to ſnuff the candle very often with a pair of ſharp ſciſſars, in order to make it burn conſtantly with the ſame degree of brilliancy; and the light of the lamp was, during the whole time, kept in the moſt exact equilibrium with the light of the candle, which was eaſily done by occaſionally drawing out, a little more or leſs, one or more of its five equal wicks. Theſe wicks, which were placed in a right line, perpendicular to a line drawn from the middle wick to the middle of the field of the photometer, were about ⅒th of an inch in diameter each, and ¼th of an inch from each other; and, when they were lighted, their flames united into one broad, thin, and very clear, white flame, without the leaſt appearance of ſmoke.

In order to aſcertain the relative conſumption of olive-oil and rape-oil, in the production of light, two lamps, like that juſt deſcribed, were made uſe of; and, the experiment being made with all poſſible care, the conſumption of olive-oil appeared to be to that of rape-oil, in the production of the ſame quantity of light, as 129 is to 125.

The experiment being afterwards repeated with olive-oil and very pure linſeed-oil, the conſumption of olive-oil appeared to be to that of linſeed-oil as 129 to 120.

The experiment being twice made with olive-oil and with a tallow candle; once when the candle, by being often ſnuffed, was made to burn conſtantly with the greateſt poſſible brilliancy, and once when it was ſuffered to burn the whole time with a very dim light, owing to the want of ſnuffing; the reſults of theſe experiments were very remarkable.

When the candle burnt with a clear, bright flame, the conſumption of the olive-oil was to the conſumption of the tallow as 129 is to 101; but when the candle burnt with a dim light, the conſumption of the olive-oil was to the conſumption of the tallow as 129 is to 229. So that it appeared, from this laſt experiment, that the tallow, inſtead of being nearly as productive of light in its combuſtion as bees wax, as it appeared to be when the candle was kept conſtantly well ſnuffed, was now, when the candle was ſuffered to burn with a dim light, by far leſs ſo than oil.

But this is not all; what is ſtill more extraordinary is, that the very ſame candle, burning with a long wick, and a dim light, actually conſumed *more tallow* than when, being properly ſnuffed, it burnt with a clear, bright flame, and gave near *three times as much light*.

To be enabled to judge of the relative quantities of light actually produced by the candle in the two experiments, it will ſuffice to know, that in order to counterbalance this light at the field of the *photometer*, it required, in the former experiment, the conſumption of 141 parts, but in the latter only the conſumption of 64 parts, of olive-oil. But in the former experiment 110, and in the latter 114, parts of tallow were actually found to be conſumed. Theſe parts were 8192ths of a Bavarian pound.

From the reſults of all the foregoing experiments, it appears that the relative expence of the undermentioned inflammable ſubſtances, in the production of light, is as follows;

		Equal Parts in Weight.
Bees wax.	A good wax-candle, kept well ſnuffed, and burning with a clear, bright flame, - - -	100
Tallow.	A good tallow candle, kept well ſnuffed, and burning with a bright flame, - - - - -	101
	The ſame tallow-candle, burning very dim for want of ſnuffing,	229
Olive-oil.	Burnt in an Argand's lamp, - -	110
	The ſame burnt in a common lamp, with a clear, bright flame, without ſmoke, - - - - -	129
Rape-oil.	Burnt in the ſame manner, - - -	125
Linſeed-oil.	Likewiſe burnt in the ſame manner, - - - - - - - -	120

With the foregoing table, and the prices current of the therein mentioned articles, the relative prices of light produced by thoſe different materials may very readily be computed.

In the year 1795, Mr J. H. Haſſenfratz was employed by the French government to make a ſeries of experiments to determine the moſt economical method of procuring light from the different combuſtible ſubſtances uſually employed for that purpoſe. The materials of his experiments were, wax, ſpermaceti, and tallow candles, fiſh-oil, oil of coleſeed, and of poppy ſeeds. In uſing theſe oils, both the Argand and common lamps were employed. The wicks of the latter were round, containing thirty-ſix cotton threads. The tallow and ſpermaceti candles were mould, ſix to the pound. The wax candles five to the pound. Mr Haſſenfratz uſed the ſame method with Count Rumford for determining the comparative intenſity of the lights.

Count Rumford, as we have ſeen, uſed the Argand lamp as a ſtandard for compariſon; but as the intenſity of its light varies according to the height of the wick, Mr Haſſenfratz preferred a wax-candle, making uſe of it ſoon after it was lighted. When two luminous bodies, of different intenſities, are put in compariſon with each other, the ſhadows are of two colours. That from the weakeſt light is blue, and from the ſtrongeſt, red. When the lights of two different combuſtible bodies are compared, they are either red or blue in a compound ratio of the colour and intenſity. Thus in comparing the ſhadows from different luminous bodies, they will be red or blue reſpectively, in the following order:

Light of the ſun.
——- of the moon.
——- of Argand lamps.
——- of tallow-candles.
——- of wax ditto.
——- of ſpermaceti ditto.
——- of common lamps.

That is to ſay, when a body is illuminated by the ſun and by any other luminous ſubſtance, the ſhadow of the former is red, and of the latter, blue. In like manner, the ſhadow from an Argand lamp is red, when placed by that of a tallow-candle, which is blue.

The following table will ſhew, according to Mr Haſſenfratz, the proportional diſtance that different luminous bodies ſhould be placed at to produce an equally intenſe ſhadow from the ſame object. The ſecond column gives the proportional intenſity of each light, which is known to be in proportion to the ſquares of the diſtances of luminous bodies giving the ſame depth of ſhadow. The third column ſhews the quantity of combuſtible matter conſumed in the hour by each mode of giving light, which Mr Haſſenfratz calculates from the average of many repeated experiments.

		Diſtance.	Intenſity.	Quantity conſumed per hour.	Quantity required for equal intenſities.
Argand lamps with	Oil of poppy ſeed	10	10.000	23	23
	— of fiſhes	10	10.000	23.77	23.77
	— of cole-ſeed	9.246	8.549	14.18	16.59
Common lamps with	Oil of cole-ſeed	6.774	4.588	8.81	19.2
	— of fiſhes	6.524	4.556	9.14	20.06
	— of poppy-ſeed	5.917	3.501	7.05	20.14
Spermaceti candle		5.917	3.501	9.23	26.37
Old tallow-candle		5.473	2.995	7.54	25.17
New ditto		5.473	2.995	8.23	27.48
Wax candle		4.275	1.827	9.54	53

The relative quantity of combuſtible matter required to produce *equal* lights at equal diſtances, may be obtained by a ſimple rule of proportion from the above data. Thus, if a given intenſity of light, expreſſed by 3.501, has been produced by a conſumption of 9.23 of ſpermaceti in the hour, the ſame luminous body will produce a light of 10.000, by conſuming in the ſame time a quantity of ſpermaceti $= \frac{10.000 \times 9.23}{3.501} = 26.37$.— Therefore we may add to the table a fourth column, expreſſing the quantity of combuſtible which each body muſt conſume to produce a light of 10.000.

From what has been laid down, it will alſo appear that the number of lights required to produce a given light, will be as follows: To produce a light equal to 100 Argand lamps, burning poppy-ſeed oil, it will require

100	Argand lamps with fiſh-oil
117	Ditto do. with cole-ſeed oil
218	Common lamps with cole-ſeed oil
219	Ditto do. with fiſh-oil
285	Ditto do. with poppy-ſeed oil
285	Spermaceti candles
333	Tallow ditto
546	Wax ditto.

Mr Haſſenfratz next takes notice of the comparative price of theſe articles; by which he finds, that in Paris the moſt expenſive light is that produced from wax-candles; and the moſt *economical*, that from oil of cole-ſeed, burned in Argand lamps.

The chief difference between the Argand and common lamp is, that in the latter much of the oil is volatilized without combuſtion, and hence the unpleaſant ſmell which it produces; whereas in the former, the heat is ſo great at the top of the wick, that all the oil is decompoſed in paſſing through, the diſpoſition of the wick allowing the free acceſs of air to aſſiſt combuſtion. It ſhould therefore follow, that the Argand lamp conſumes leſs fuel to produce a given light than the common lamp, and this, as we have ſeen, is the opinion of Count Rumford. Yet (Mr Haſſenfratz obſerves) there are two circumſtances that prevent the full effect of the complete combuſtion in the Argand lamp. The one is, that the glaſs cylinder abſorbs a part of the rays of light as they paſs through; the other, that the column of light proceeding from the inner ſurface of the wick, is, in part, loſt, by being obliged to paſs through that from the outer ſurface. Count Rumford allows the firſt cauſe of diminution of light, and eſtimates it at .1854, but not the latter. The author of this memoir, in repeating Count Rumford's experiments, aſſerts, that when two candles are placed ſo that the light of the one is obliged to paſs through that of the other, the ſum of the light ſo produced is not ſo ſtrong as when they are placed ſide by ſide; for in the firſt caſe, a part of the hindmoſt light is abſorbed by the foremoſt.

LANCASHIRE. In the account which we have given of that county in the *Encyclopædia*, an obliging correſpondent has pointed out to us ſome miſtakes. He aſſures us, that the ſea coaſt, where we underſtood the atmoſphere to be loaded with ſuch exhalations as produce malignant and intermitting fevers, is remarkably healthy; and he ſpeaks from experience, having lived on that coaſt for forty years. He aſſures us likewiſe, that the Duke of Bridgewater's inland navigation was begun ſoon after, if not before, the year 1736, and that he (the writer), ſo early as 1764, was one of a party who ſailed up the ſough or edit a conſiderable way to ſee how the coals were worked. The ſame correſpondent has pointed out a few miſtakes in our account of

LANCASTER, the capital of the county. "That town (he ſays) carries on no trade whatever with North America, but a very conſiderable one with Jamaica and the other Weſt India iſlands, in veſſels of from 100 to 500 tons burthen. It exports to theſe iſlands all ſuch Britiſh manufactures as they have occaſion for, Iriſh linens, and ſalted proviſions of all kinds, ſuch as Iriſh beef, pork, butter, &c. It trades alſo to the Baltic, Portugal, Hamburgh, &c. to a large amount; and ſome of its ſhips with their cargoes have of late been worth from L.60 to L.80,000 ſterling. It has, however, no communication by water with the rivers Merſey, Dee, &c. as we have ſaid; the canal reaching as yet no farther than to near Preſton in Lancaſhire." The communication with theſe rivers is indeed intended to be completed; but whether the ſcheme be practicable is, according to our correſpondent, very uncertain.

LANTERN (See *Encycl.*). Sir George Staunton informs us, that of the Chineſe lanterns, ſome were ſuch as we have deſcribed, *viz.* compoſed of thin ſilk gauze, painted or wrought in needle-work with figures of birds, inſects, flowers, or fruit, and ſtretched on neat frames of wood. Others, however, were very different, being entirely made of horn. Theſe were ſo thin and tranſparent, that they were taken at firſt for glaſs; a material to which, for this purpoſe, the horn is preferred by the Chineſe, as cheaper, lighter, leſs liable to accident, and, in caſe of accident, more eaſily repaired; many of them were about two feet in the diameter, and in the form of a cylinder, with the ends rounded off, and the edges meeting in the point to which the ſuſpending cords were tied. Each lantern conſiſted of an uniform piece of horn, the joints, or ſeams, being rendered inviſible by an art found out by the Chineſe; among whom, the vaſt number of ſuch lanterns uſed in their dwelling houſes and temples, as well as on the occaſions of their feſtivals and proceſſions, have led to many trials for improving their conſtruction. The horns generally employed are thoſe of ſheep and goats. The uſual method of managing them, according to the information obtained upon the ſpot, is to bend them by immerſion in boiling water, after which they are cut open and flattened; they then eaſily ſcale, or are ſeparated into two or three thin laminæ or plates. In order that theſe plates ſhould be made to join, they are expoſed to the penetrating effect of ſteam, by which they are rendered almoſt perfectly ſoft. In this ſtate the edges of the pieces to be joined are carefully ſcraped and ſlanted off, ſo as that the pieces overlapping each other ſhall not together exceed the thickneſs of the plate in any other part. By applying the edges, thus prepared, immediately to each other, and preſſing them with pincers, they intimately adhere, and incorporating, form one ſubſtance, ſimilar in every reſpect to the other parts; and thus uniform pieces of horn may be prepared to almoſt any extent. It is a contrivance little known elſewhere, however ſimple the proceſs appears to be; and perhaps ſome minute precautions are omitted in the general deſcription, which may be eſſential to its complete ſucceſs.

Such lanterns as theſe would be very proper for military ſtore houſes; and Rochon of *the National Inſtitute* was employed, ſince the commencement of the preſent war, to make them, if he could, for the marine ſtorehouſes of France. While he was thus engaged, however, it occurred to him, that he might ſupply the preſſing wants of the navy without horn, merely by filling up the interſtices of wire-cloth with fine tranſparent glue. In carrying this thought into execution, he at firſt tinned the iron wires of the ſieve cloth he made uſe of; but afterwards found it more convenient, in every reſpect, to give it a ſlight coating of oil paint to preſerve it from ruſt. The glue he made uſe of was afforded by boiling the clippings of parchment with the air bladders and membranes of ſea fiſh; materials which he uſed, not from any notion that they were preferable to iſinglaſs, but becauſe they were the cheapeſt he could procure. He added the juice of garlic and cyder to his compoſition, in ſuch proportions as he found to communicate great tenacity, and ſomewhat more of tranſparence than it would have poſſeſſed without them. Into this tranſparent and very pure glue or ſize he plunged his wire cloth, which came out with its interſtices filled with the compound. It is requiſite that the ſize ſhould poſſeſs a determinate heat and conſiſtence, concerning which experience alone muſt guide the operator.

When this prepared wire cloth is fixed in the lantern, it muſt be defended from moiſture by a coating of pure drying linſeed oil; but even in this ſtate it is not fit to be expoſed to the weather. The eaſe with which theſe lanterns are repaired in caſe of accident, by a ſlight coating of glue, is pointed out as a great advantage by the inventor; who likewiſe informs us, that they were uſed in the expedition to Ireland as ſignal lanterns, though contrary to his wiſhes.

LAPIS Fungifer, a ſpecies of earth found near Rome, Naples, and Florence, of which the following account is taken from the *New Tranſactions of the Royal Academy of Sciences at Stockholm* for the year 1797: Near Naples the lapis fungifer is found in the chalk-hills like a white ſtalactites, intermixed with a great many fine roots of ſhrubs; and near Florence there is a ſpecies of it, conſiſting of hardened turf, which is dug up near volcanoes. The author made experiments with a piece procured from Italy, and found that 100 parts contain from 45 to 46 ſiliceous earth, 23 argillaceous earth, 7 calcareous earth, and 20 calx of iron, with ſome white magneſia and vegetable alkali. It is well known, that when this friable ſpecies of ſtone is preſerved in cellars and moiſtened with water, it produces abundance of eatable muſhrooms, which in Italy are highly eſteemed and brought to the firſt tables. Hence the origin of its name.

LARDIZABALA, a new genus of plants belonging to the *diœcia hexandria* of Linnæus. It is a native of Chili, and is thus deſcribed in Perouſe's Voyage, from drawings ſent to France by La Martiniere. The leaves are alternate, on footſtalks inflated at their baſe. Each leaf is bi-ternate, that is to ſay, it is divided into three leaflets, each of which is again ſubdivided into three oval ſharp-pointed folioles, which, when young, are entire, but afterwards become obſcurely lobed. The flowers, diſpoſed in ſimple and pendent cluſters, grow towards the top of the ſtem and of the branches in the axillæ of the leaves. The plant is diœcius. At the baſe of each cluſter of bloſſoms are two ſmall, rounded, oval, floral leaves.

Plate XXX.

Male Flower.—*Calyx* formed of ſix expanding leaves, oblong oval, and obtuſe, of which the three outermoſt are the largeſt. *Corolla* compoſed of ſix ſharp lanceolated petals, oppoſite to, and ſhorter than, the leaves of the calyx. A cylinder riſes from the centre of the flower of the length of the petals, terminated by ſix oblong bilocular anthers, which open from below.

Female Flower.—*Calyx*, ſimilar to that of the male flower, but larger. *Corolla* inſerted beneath the piſtil compoſed of ſix petals, rarely entire, but generally bifid or trifid at their ſummit: ſhorter than the leaves of the calyx. *Stamina* ſix, having the ſame inſertion as the corolla; filaments diſtinct, broad, very ſhort, ſurrounding the piſtil; *anthers*, ſix, upright, oblong, acuminated, barren. *Seed bud*, cells, from three to ſix, oblong, gibbous on the outſide, of nearly the length of the corolla; ſtyles none; ſtigmata, ſitting, oblong, permanent. *Berries*, equal in number to the cells, oblong, acuminated (divided into ſix cells, containing ſeveral angular ſeeds. *Flora Peruviana).*

The general character of the lardizabala evidently places this new genus among the family of the *meniſpermæ*, to which it is related by its climbing ſtalk, its bunches of diœcious flowers, by its ſix petals, ſtamina, and leaves of its calyx, by its piſtil, compoſed of from three to ſix cells, which contain as many ſeeds. It differs from the known genera of this order only in its fruit, which, inſtead of being monoſpermous, contains ſeveral ſeeds. This character, which requires the introduction of a new ſection into the *meniſpermæ*, ſtrengthens the relation of this family to the next order of the *anonæ*. In fact, the greater part of the genera of the anonæ, as they have in the ſame flower ſeveral fruits, with numerous ſeeds, differ in this particular from all the genera of the meniſpermæ; and by placing between them the lardizabala, we eſtabliſh a natural tranſition. In order to confirm theſe reſemblances, it only remains to examine the inſide of the fruit, and particularly the ſtructure of the ſeeds. Thoſe of the meniſpermæ are reniform, at leaſt on the inſide, incloſed in a hinged pericarpium, and containing in their upper part a very ſmall dicotyledonus embryo. The characters that we have given of the lardizabala render probable a ſimilar ſtructure in its ſeeds.

LARMIER, in architecture, a flat ſquare member of the cornice below the cimaſium, and jets out fartheſt; being ſo called from its uſe, which is to diſperſe the water, and cauſe it to fall at a diſtance from the wall, drop by drop, or, as it were, by tears; *larme* in French ſignifying a tear.

LATUS Primarium, a right line drawn through the vertex of the ſection of a cone, within the ſame, and parallel to the baſe.

Latus Rectum. See *Conic Section*, Encycl.

Latus Tranſverſum of the hyperbola, is the right line between the vertices of the two oppoſite ſections, or that part of their common axis lying between the two oppoſite cones.

LAVA. In addition to the obſervations of Sir William Hamilton, Bergmann, Formes, and Dalmieu, on the compoſition of different lavas, which have been given in the *Encyclopædia*, we cannot refuſe ourſelves the pleaſure of noticing, in this place, thoſe of Sir James Hall. From a number of well-deviſed experiments, Sir James thinks himſelf warranted to conclude, that lava and whinſtone are intrinſically the ſame ſubſtance; and that their apparent differences ariſe wholly from the circumſtances under which they have paſſed from a liquid to a ſolid ſtate. The lavas, it is well known, have been cooled rapidly in the open air, and the whins (according to Dr Hutton's theory, which Sir James ſeems willing to adopt) ſlowly in the bowels of the earth.

Though we are far from adopting that theory in all its parts, to which we think inſuperable objections may be made (ſee Earth, *Encycl.* n° 120), we admit, that the experiments of Sir James Hall go far to eſtabliſh the identity of lava and whinſtone. Theſe experiments were made upon ſeven different ſpecies of whinſtone and ſix lavas, of which four were broken from the currents of Etna and Veſuvius by Sir James himſelf. Each of the original whinſtones was reduced, by fuſion and ſubſequent rapid cooling, to a ſtate of perfect glaſs. This glaſs, being again placed in the furnace, was ſubjected to a ſecond fuſion. The heat, being then reduced to a temperature generally about 28° of Wedgewood, was maintained ſtationary for ſome hours; when the crucible was either immediately removed, or allowed to cool with the furnace. The conſequence was, that in every caſe the ſubſtance had loſt the character of glaſs, and by cryſtallization had aſſumed in all reſpects that of an original whinſtone. It muſt be owned, that in moſt caſes the new production did not exactly reſemble the particular original from which it was formed, ed, but ſome other original of the ſame claſs; owing to accidental varieties in the mode of refrigeration, and to chemical changes which unavoidably took place during the proceſs. In the caſe, however, of the rock of Edinburgh caſtle, and of that of the baſaltic columns of Staffa, the artificial ſubſtances bear a complete reſemblance to their originals, both in colour and texture.

The lavas were now treated in the ſame way, and were each, by fuſion and rapid cooling, reduced, as the whinſtones had been, to glaſs. This glaſs, when fuſed again and cooled ſlowly, yielded the ſame kind of cryſtallized, ſtony, or earthy maſſes, completely reſembling an original whin or lava.

Although the internal ſtructure of lava was thus accounted for, yet Sir James was embarraſſed with the ſtate of its external ſurface; which, though cooled in contact with the open air, is ſeldom or never vitreous, holding an intermediate ſtation between glaſs and ſtone; but this difficulty was removed by a circumſtance which took place in the courſe of theſe experiments. It was found, that a ſmall piece of glaſs of any of the lavas, or of ſeveral of the whins, being introduced into a muffle, the temperature of which was at any point between the 20th and the 22d degree of Wedgewood's ſcale, the glaſs became quite ſoft in the ſpace of one minute; but, being allowed to remain till the end of a ſecond minute, it was found to have become hard throughout in conſequence of a rapid cryſtallization, to have loſt its character of glaſs, and to have become by 12 or 14 degrees more infuſible, being unaffected by any heat under 30, though the glaſs had been fuſible at 18° or at 16°. This accounted for the ſcoria on the ſurface of lavas; for the ſubſtance even at the ſurface, being in contact with the flowing ſtream, and ſurrounded with heated air, could not cool with exceſſive rapidity: and the experiment ſhews, that ſhould any part of the maſs, in deſcending heat, employ more than one or two minutes in cooling from 22 to 20, it would infallibly loſe its vitreous character.

Independently of any alluſion to ſyſtem or to general theory, Sir James Hall flatters himſelf that theſe experiments may be of ſome importance, by ſimplifying the hiſtory of volcanoes; and, above all, by ſuperſeding ſome very extraordinary, and, he conceives, unphiloſophical opinions advanced with regard to volcanic heat, which has been ſtated as poſſeſſing very little intenſity, and as acting by ſome occult and inconceivable influence, or with the help of ſome inviſible agent, ſo as to produce liquidity without fuſion. Theſe ſuppoſitions, which have been maintained ſeriouſly by ſome of the moſt celebrated naturaliſts in Europe, have originated from the difficulty of accounting for the ſtony character of lavas when compared with that of glaſs, which they aſſume in conſequence of fuſion in our furnaces. But now he hopes we may be relieved from the neceſſity of ſuch violent efforts of imagination, ſince the phenomena have been fully accounted for by the ſimple, though unnoticed, principle of refrigeration, and have been repeated again and again with eaſe and certainty in a ſmall chamber furnace.

LAVOISIER (Antoine Laurent), was born in Paris on the 26th of Auguſt 1743. His father, who directed his education, was opulent, and ſpared no coſt for his improvement. The youth ſhewed a decided taſte for the phyſical ſciences. In 1764, government having propoſed an extraordinary premium for the beſt and cheapeſt mode of lighting the ſtreets of a large city, Lavoiſier obtained the gold medal; and his memoir, full of nice inveſtigation, was printed by the Academy. Into that body he was received on the 13th May 1768, in ſpite of a formidable oppoſition; and to its ſervice he ever after devoted his labours, and became one of its moſt uſeful aſſociates and coadjutors.

His attention was ſucceſſively occupied with every branch of phyſical and mathematical ſcience. The pretended converſion of water into earth, the analyſis of gypſum in the neighbourhood of Paris, the cryſtallization of ſalts, the effects produced by the *grande de loupe* of the garden of the Infanta, the project of bringing water from l'Yvette to Paris, the congelation of water, and the phenomena of thunder and the aurora borealis—all occupied his attention.

Journeys, undertaken in concert with Guettard into every diſtrict of France, enabled him to procure numberleſs materials towards a deſcription of the lithological and mineralogical empire; theſe he arranged into a kind of chart, which wanted little of being completed. They ſerved alſo as a foundation for a more laborious work of his on the revolutions of the globe, and the formation of *Couches de la Terre;* a work of which two beautiful ſketches are to be ſeen in the Memoirs of the French Academy for 1772 and 1787. All the fortune and all the time of Lavoiſier were devoted to the culture of the ſciences; nor did he ſeem to have a preponderating inclination for any one in particular, until an event, ſuch as ſeldom occurs in the annals of the human mind, decided his choice, and attached him thenceforth excluſively to chemiſtry—a purſuit which has ſince rendered his name immortal.

The important diſcovery of gaſes was juſt announced to the philoſophical world. Black, Prieſtley, Scheele, Cavendiſh, and Macbride, had opened to phyſiologiſts a ſort of new creation; they had commenced a new era in the annals of genius, which was to become equally memorable with thoſe of the compaſs, printing, electricity, &c.

It was about the year 1770 that Lavoiſier, ſtruck with the importance and grandeur of this diſcovery, turned his attention to this inexhauſtible fountain of truths, and inſtantly perceived, by a kind of inſtinct, the glorious career which lay before him, and the influence which this new ſcience would neceſſarily have over the whole train of phyſical reſearches. Of thoſe who had preceded him, the moſt indefatigable experimenter was Prieſtley: but facts the moſt brilliant remained frequently unproductive in his hands; on every occaſion he was ready to frame ſome crude hypotheſis, which as haſtily he abandoned. Lavoiſier was imbued with the true ſpirit of inductive philoſophy; his obſervations, eminently preciſe and luminous, always pointed to general views. In 1774, he publiſhed his chemical opuſcules, which contained a very neat hiſtory of all that had been done with reſpect to gaſes, and concluded with the author's capital experiments, by which it was proved, that metals, in calcination, derive their augmentation of weight from the abſorption of air. Soon afterward, he ſhewed, in oppoſition to Prieſtley, that nitrous acid is compoſed of air; a remark, of which the importance appeared in the ſequel. His ingenuity as a chemiſt was now ſo well known, that in 1776 Turgot employed him to inſpect the manufacture of gun-powder. He introduced ſome valuable improvements, and, ſuppreſſing the odious viſits in queſt of the materials of ſaltpetre, he yet quintupled its produce. The gun powder would now carry 120 toiſes, when formerly it would not reach 90. This ſuperiority was indeed acknowledged in the laſt war.

It had been alleged, that by frequent diſtillation water is converted into earth. This queſtion Lavoiſier reſolved in 1778, having ſhewn that the earthy ſediment was owing to the continual eroſion of the internal ſurface of the retort. In that ſame year he made a more intereſting diſcovery; namely, that the reſpirable portion of the atmoſphere is a conſtituent principle of all acids, and which he therefore denominated *oxygen;* a moſt important fact, and the firſt great ſtep towards the new chemiſtry; which the compoſition of water, aſcertained in 1783, triumphantly completed.

Lavoiſier poſſeſſed deciſive advantages over his contemporaries; he ſtudied a geometrical accuracy of inveſtigation; and his wealth enabled him to make experiments on a large ſcale, and to uſe inſtruments of the moſt perfect conſtruction. He was able to hold in his houſe, twice every week, aſſemblies, to which he invited every literary character that was moſt celebrated in geometrical, phyſical, and chemical, ſtudies; in theſe inſtructive *converſationes*, diſcuſſions, not unlike ſuch as preceded the firſt eſtabliſhment of academies, regularly took place. Here the opinions of the moſt eminent literati in Europe were canvaſſed; paſſages the moſt ſtriking and novel, out of foreign writers, were recited and animadverted on; and theories were compared with experiments. Here learned men of all nations found eaſy admiſſion; Prieſtley, Fontana, Blagden, Ingenhouſz, Landriani, Jacquin, Watt, Bolton, and other illuſtrious phyſiologiſts and chemiſts of England, Germany, and Italy, found themſelves mixed in the ſame company with La Place, La Grange, Borda, Couſin, Meunier, Vandermonde, Monge, Morveau, and Berthollet. Happy hours paſſed in theſe learned interviews, wherein no ſubject was left uninveſtigated that could poſſibly contribute to the progreſs of the ſciences, and the amelioration and happineſs of man. One of the greateſt benefits reſulting from theſe aſſemblages, and the influence of which was ſoon afterwards felt in the academy itſelf, and conſequently in all the phyſical and chemical works that have been publiſhed for the laſt twenty years in France, was the agreement eſtabliſhed in the methods of reaſoning between the natural philoſophers and the geometricians. The preciſion, the ſeverity of ſtyle, the philoſophical method of the latter, was inſenſibly transfuſed into the minds of the former; the philoſophers became diſciplined in the tactics of the geometricians, and were gradually moulded into their reſemblance.

It was in the aſſemblage of theſe talents that Lavoiſier embelliſhed and improved his own. When any new reſult from ſome important experiment preſented itſelf, a reſult which threatened to influence the whole theory of the ſcience, or which contradicted theories till then adopted, he repeated it before this ſelect ſociety. Many times ſucceſſively he invited the ſevereſt objections of his critical friends; and it was not till after he had ſurmounted their objections, to the conviction and entire perſuaſion of the ſociety; it was not till after he had removed from it all myſtery and obſcurity, that he ventured to announce to the world any diſcovery of his own.

At length he combined his philoſophical views into a conſiſtent body, which he publiſhed in 1789, under the title of *Elements of Chemiſtry*; a book which is a moſt beautiful model of ſcientific compoſition, clear, logical, and elegant. It would be foreign to our purpoſe to attempt an expoſition of the principles, or to expatiate on the merits, of this celebrated ſyſtem; which, within the ſpace of a very few years, has been almoſt univerſally adopted, and which, if not the genuine interpretation of nature, approaches as near to it as the preſent ſtate of knowledge will permit. See CHEMISTRY in this *Supplement*.

The laſt, but not the leaſt uſeful, of Lavoiſier's philoſophical reſearches, on the Perſpiration of Animals, was read to the Academy on the 4th May 1791, and of which part was publiſhed in the volume for 1790. He found, by ſome delicate experiments, made in conjunction with Seguin, that a man in 24 hours perſpires 45 ounces; that he conſumes 33 ounces of vital air; that he diſcharges from the lungs 8 cubic feet of carbonic acid gas, of which one-third is carbon and two-thirds are oxygen; that the weight of water diſcharged from the lungs amounts to 23 ounces, of which 3 are hydrogen and 20 oxygen, excluſive of 6 ounces of water already formed, loſt in pulmonary perſpiration. Theſe diſcoveries were directed to the improvement of medicine.

We have mentioned the aſſiſtance which Lavoiſier received while he was digeſting his new ſyſtem of chemiſtry; but we muſt add, that to him pertains excluſively the honour of a founder. His own genius was his ſole conductor, and the talents of his aſſociates were chiefly uſeful in illuſtrating diſcoveries he himſelf had made; he firſt traced the plan of the revolution he had been a long time conceiving; and his colleagues had only to purſue and execute his ideas.

In the twenty volumes of the Academy of Sciences, from 1772 to 1793, are 40 memoirs of Lavoiſier, replete with all the grand phenomena of the ſcience; the doctrine of combuſtion, general and particular; the nature and analyſis of atmoſpherical air; the formation and fixation of elaſtic fluids; the properties of the matter of heat; the compoſition of acids; the augmentation of the ponderoſity of burnt bodies; the decompoſition and recompoſition of water; the diſſolution of metals; vegetation, fermentation, and animalization. For more than 15 years conſecutive, Lavoiſier purſued, with unſhaken conſtancy, the route he had marked out for himſelf, without making a ſingle falſe ſtep, or ſuffering his ardour to be damped by the numerous and increaſing obſtacles which conſtantly beſet him.

Many were the ſervices rendered by Lavoiſier, in a public and private capacity, to manufactures, to the ſciences, and to artiſts. He was treaſurer to the Academy after Buffon and Tillet, and introduced economy and order into the accounts. He was alſo a member of the Board of Conſultation, and took an active ſhare in whatever was going forwards. When the new ſyſtem of meaſures was agitated, and it was propoſed to determine a degree of the meridian, he made accurate experiments on the expanſion of metals, and conſtructed a metalline thermometer. By the National Convention he was conſulted on the means of improving the manufacture of aſſignats, and of increaſing the difficulties of forging them.

Like a good citizen, Lavoiſier turned his thoughts to political economy. Between the years 1778 and 1785, he allotted 240 *arpents* in the Vendômois to experimental agriculture, and increaſed the uſual produce by one-half. In 1791, he was invited by the Conſtituent Aſſembly to digeſt a plan for ſimplifying the collection of the taxes. This gave occaſion to an excellent report, afterwards printed with the title of *Territorial Riches of France*. At this time, alſo, he was appointed commiſſioner of the national treaſury, in which he effected ſome beneficial reforms.

During the horrors of the Robeſpierrean dictatorſhip, Lavoiſier told La Lande that he foreſaw he ſhould be ſtripped of his property, but that he would work for his bread. The profeſſion of apothecary would have ſuited him the beſt. But his doom was already fixed. On the 8th of May 1794, confounded with 28 farmers-general, he ſuffered on the ſcaffold, merely becauſe he was rich!

Lavoiſier was tall, and of a graceful, ſprightly appearance. He was mild, ſociable, obliging, and extremely active; and in his manners he was unaffectedly plain and ſimple. Many young men, not bleſſed with the gifts of fortune, but incited by their genius to woo the ſciences, have confeſſed their obligations to him for pecuniary aid; many, alſo, were the unfortunate whom he relieved in ſilence, and without the oſtentation of virtue. In the communes of the department of the *Loir* and *Char*, where he poſſeſſed conſiderable eſtates, he would frequently viſit the cottages of indigence and diſtreſs; and long will his memory be cheriſhed there. But his reputation, influence, virtues, and wealth, gave him a great preponderance, which unfortunately provoked the jealouſy of a crew of homicides, who made a ſport of ſacrificing the lives of the beſt of men to a ſanguinary idol.

This great and good man married, in 1771, Marie-Anni-Pierette Paulze, daughter of a farmer-general; a woman whoſe wit and accompliſhments conſtituted the charm of his life; who aſſiſted him in his labours, and even engraved the figures of his laſt work.

LEAD. See that article (*Encycl.*), and Chemiſtry-*Index* in this *Supplement*. It is well known, that lead generally contains a portion of ſilver, and ſometimes of gold; and that there are occaſions, particularly in aſſaying, when it is of importance to have it freed from theſe metals. For accompliſhing theſe purpoſes different proceſſes have been propoſed; but the following by Pet. Jac. Hjelm, as it is the leaſt expenſive, promiſes to be the moſt uſeful:

Litharge (ſee *Encycl.*) was the ſubſtance on which this chemiſt made his experiments, and his principal object was to free it from all mixture of ſilver. This was accompliſhed in the following manner: He placed a crucible, in which half a pound of litharge found good room, and which was fitted with a cloſe cover, in a wind-furnace filled with dead coals. He then put into the crucible a mixture of four ounces of potaſh and the ſame quantity of powder of flint. When the whole was well melted by ſtrengthening the draught, and making the coals glow, he took off the cover, and laid hold of the crucible with a pair of tongs, in order to take it out, and to ſuffer this very fuſible glaſs to cover the inſide of the crucible, to ſecure it from the glaſs of the lead which he meant to melt in it. The ſuperfluous glaſs was poured out; the crucible again placed on its foot, and half a pound of litharge thrown into it with a ſhovel. The cover was placed upon it while the litharge was melting; and when it was thoroughly glowing and fluid, charcoal duſt was ſifted into the uncovered crucible through a ſieve, ſo that the ſurface of the litharge was completely covered with it. This immediately produced an efferveſcence, and the riſing of bubbles, by means of the ſeparation of the air occaſioned by the reduction of the lead. During this proceſs, the cover was put on, and a few coals thrown into the furnace: when theſe were burnt, every thing in the crucible was quiet, and the melted maſs was poured into a warm conical mould. The crucible was then again filled with half a pound of the ſame kind of litharge, and put into the furnace, and charcoal duſt was ſeveral times ſifted over the melted ſurface, till it was well covered before the maſs was thrown out, a ſufficient ſpace being every time left for the efferveſcence. The firſt maſs had, in the mean time, become cool, and, on examination, contained four ounces of lead at the bottom, and litharge at the top. When this litharge was reduced with potaſhes and wine ſtone, the lead thence obtained, which weighed 23 ounces, was found to contain leſs than one-half grain of ſilver in the pound. In the ſecond maſs there was found ſomewhat more than ſix ounces of lead, which contained all the ſilver that had been before mixed with the litharge, becauſe in the lead which had been reduced from the litharge in the above manner, there were no perceptible traces of ſilver. This lead was then melted over a ſlow fire, and caſt into bars, which were rolled ſmooth, and formed into maſſes of a known weight, to be uſed for aſſaying gold and ſilver, and for other purpoſes of the ſame kind. All theſe meltings were made in one crucible, which, according to every appearance, remained unhurt. If the ſame experiments were made with red lead, the like reſult would infallibly follow.

With the ſame view of obtaining lead free from ſilver, he melted, in the like manner, half a pound of white lead, which produced half an ounce of lead. When the litharge ſtanding over it was revived, the lead obtained was ſtill found to contain too much ſilver. He therefore precipitated another half pound of white lead by charcoal powder, after the lead that fell from it had been ſeparated: and then it produced, by reviving, a maſs of lead without any mixture of ſilver.

LEDYARD (—— ——), the celebrated, though unfortunate, traveller, was a native of North America, but of what province we have not learned. We are equally ignorant of the year of his birth, and the rank of his parents; but have no reaſon to think that they were opulent. From his early youth he diſplayed a ſtrong propenſity to viſit unknown and ſavage countries; and to gratify that propenſity, he lived for ſeveral years with the American Indians, whoſe manners and habits he ſeemed in ſome degree to have acquired. Afterwards he ſailed round the world with Captain Cook in the humble ſtation of a corporal of marines; and on his return, he determined to traverſe the vaſt continent of America, from the Pacific to the Atlantic Ocean.

This deſign being fruſtrated by his not obtaining a paſſage to Nootka Sound, he determined to travel over land to Kamſchatka. With this view he went over to Oſtend, with only ten guineas in his pocket, and proceeded by the way of Denmark and the Sound to the capital of Sweden, and endeavoured to croſs the Gulph of Bothnia on the ice; but finding, when he came to the middle, that the water was not frozen, he walked round the gulph to Peterſburgh. Here he found himſelf without ſtockings or ſhoes; but procured relief from the Portugueſe ambaſſador, and obtained leave to proceed with a detachment of ſtores to Yakutz. He made this journey of ſix thouſand miles, and there met Mr Billengs, an Engliſhman, whom he had known on board Captain Cook's ſhip. From thence he went to Oczakow, on the coaſt of the Kamſchatka Sea; but being too late to embark that year, returned to Yakutz to winter. Here he was, on ſome ſuſpicion, ſeized, conveyed on a ſledge through Northern Tartary, and left on the frontiers of the Poliſh dominions. In the midſt of poverty, rags, and diſeaſe, he however reached Koningſburg, where he found friends that enabled him to reach England.

On his arrival in London, he waited on Sir Joſeph Banks, on whoſe credit he had, in his diſtreſs, received at different times 25 guineas. Sir Joſeph communicated to him the views of the African Aſſociation, and pointed out the route in which they wiſhed Africa to be explored. On his engaging at once in the enterpriſe, Sir Joſeph aſked him when he would be able to ſet out. "To-morrow morning," replied Ledyard, without heſitation. At this interview the preſident of the Royal Society declares, that he was ſtruck with the figure of the man, the breadth of his cheſt, the openneſs of his countenance, and the rolling of his eye. Though ſcarcely exceeding the middle ſize, his figure indicated great ſtrength and activity. Deſpiſing the accidental diſtinctions of ſociety, he ſeemed to regard no man as his ſuperior; but his manners, though coarſe, were not diſagreeable. His uncultivated genius was original and comprehenſive. From the native energy of his mind, he was adventurous, curious, and unappalled by dangers; while the ſtrength of his judgment united caution with energy. The track pointed out to him was from Cairo to Senaar, and thence weſtward in the latitude and ſuppoſed direction of the Niger.

He was not ignorant, that the taſk aſſigned him was arduous and big with danger; but inſtead of ſhrinking from it, he ſaid, on the day of his departure, "I am accuſtomed to hardſhips; I have known both hunger and nakedneſs to the utmoſt extremity of human ſuffering; I have known what it is to have food given me as charity to a madman; and I have at times been obliged to ſhelter myſelf under the miſeries of that character to avoid a heavier calamity. My diſtreſſes have been greater than I ever owned, or ever will own to any man. Such evils are terrible to bear, but they never yet had power to turn me from my purpoſe. If I live, I will faithfully perform, in its utmoſt extent, my engagement to the Society: and if I periſh in the attempt, my honour will be ſafe; for death cancels all bonds."

After receiving his inſtructions and letters of recommendation, this intrepid traveller ſailed from London on the 30th of June 1788; and in 36 days arrived at Alexandria. Proceeding to Cairo, where he arrived Auguſt the 17th, he viſited the ſlave markets, and converſed with the travelling merchants of the caravans. Theſe ſources of information, generally neglected by travellers, enabled him to obtain, at a very ſmall expence, more correct information concerning the African nations and their trade, the poſition of places, the nature of the country, the manner of travelling, &c. than could have been eaſily obtained by any other method. He thus learned, that the Arabs of the deſert have an invincible attachment to liberty, though it is ſingular that they have no word to expreſs liberty in their language. The Mahomedans of Africa are a trading, ſuperſtitious, and warlike ſet of vagabonds. He ſaw near 200 black ſlaves expoſed to ſale, who had been brought from the interior parts of Africa; their appearance ſavage, but not like priſoners of war; they had head ornaments, and their hair plaited in detached plaits of great length. Another parcel, which had come from Darfoor, were moſtly women; and the beads, and ſome other ornaments which they wore, were Venetian. They were well formed, quite black, had the true Guinea face, and curled hair. Mr Ledyard was informed, that the king of Senaar was a merchant, and concerned in the caravans; that 20,000 negro ſlaves are imported into Egypt annually. Among ſome Senaar ſlaves, he ſaw three of a bright olive colour, but their heads uncommonly formed, the forehead the narroweſt, longeſt, and moſt protuberant he ever ſaw.

The Senaar caravan is the moſt rich; that of Darfoor is not equally ſo, though it trades with almoſt the ſame commodities. Beſides ſlaves, theſe are gum, elephants teeth, camels, and oſtrich-feathers; for which are received in exchange trinkets, ſoap, antimony, red linen, razors, ſciſſars, mirrors, and beads. Wangara, to which the caravans alſo trade, was repreſented to Mr Ledyard as a kingdom producing much gold; but the king ſeems to intermeddle with commerce as well as the potentate of Senaar; for in order to deceive ſtrangers, and prevent them from gueſſing at the extent of his riches, he was reported to vary continually the gold uſed in barter, which it is his province to regulate, and of which he iſſues at one time a great quantity, and at others little or none. A caravan goes from Cairo to Fezzan, which they call a journey of fifty days; and as the caravans travel about 20 miles a day, the diſtance muſt be about 1000 miles; from Fezzan to Tombuctoo is 1800 miles; from Cairo to Senaar about 600 miles.

Such was the information which Mr Ledyard derived from the merchants of the caravans in Egypt; but when he was about to verify it by his own obſervations, and had announced to the Aſſociation that his next diſpatch would be dated from Senaar, he was ſeized with a bilious complaint, which fruſtrated the ſkill of the moſt eminent phyſicians, and put a period to his travels and his life at Cairo. It is needleſs to ſay how much his death was regretted, or how well he was qualified for the arduous enterpriſe in which he had engaged. The perſon who, with ſuch ſcanty funds, could penetrate the frozen regions of Tartary, ſubſiſt among their churliſh inhabitants, and ingratiate himſelf with the ferocious Moors of Egypt, could hardly have failed to obtain a kind reception from the gentle and hoſpitable Negro, had no untoward circumſtance intervened. At Senaar, indeed, his riſk would have been great; and Mr Bruce was decidedly of opinion, that a man ſo poorly attended as Mr Ledyard, could never have made his eſcape from that treacherous and ferocious people.

The obſervations of this accurate obſerver on the female character, though they have been repeatedly quoted in other works, are well intitled to a place here; and with them we ſhall conclude this ſketch of his life: "I have always (ſays he) remarked, that women in all countries are civil and obliging, tender and humane; that they are ever inclined to be gay and cheerful, timorous and modeſt; and that they do not heſitate, like man, to perform a generous action. Not haughty, not arrogant, not ſupercilious; they are full of courteſy, and fond of ſociety; more liable, in general, to err than man; but in general alſo more virtuous, and performing more good actions than he. To a woman, whether civilized or ſavage, I never addreſſed myſelf, in the language of decency and friendſhip, without receiving a decent and friendly anſwer. With man it has often been otherwiſe. In wandering over the barren plains of inhoſpitable Denmark, through honeſt Sweden, and frozen Lapland, rude and churliſh Finland, unprincipled Ruſſia, and the wide ſpread regions of the wandering Tartar; if hungry, dry, cold, wet, or ſick, the women have ever been friendly to me, and uniformly ſo. And to add to this virtue (ſo worthy the appellation of benevolence), theſe actions have been performed in ſo free and kind a manner, that if I was dry, I drank the ſweeteſt draught; and if hungry, I eat the coarſeſt morſel with a double reliſh." For a fuller account of *Ledyard*, ſee *The Tranſactions of the African Aſſociation*, or *A View of the Late Diſcoveries in Africa.*

Hyperbolic LEGS, are the ends of a curve line that partakes of the nature of the hyperbola, or having aſymptots.

LEMINGTON Priors, is a village two miles eaſt of the town of Warwick, famous for its mineral waters. One ſalt ſpring, which riſes near the church yard, has been long known, as well as another which riſes in the bed of the river; but the moſt remarkable ſpring was diſcovered in the year 1790. The waters of both ſprings have been analyzed with great accuracy by William Lambe, M. A. late Fellow of St John's colledge, Cambridge, who has given us the following ſynoptical table of the ſubſtances contained in them:

Gaſeous Fluids contained in a Wine-gallon in Cubic Inches.

	WATER OF THE NEW SPRING.	WATER OF THE OLD SPRING.
Hepatic gas -	*Too ſmall to be meaſured.*	*Too ſmall to be meaſured.*
Azotic gas -	3.5	3
Carbonic acid gas	.5	—

Solid contents of a Wine-gallon in Grains.

	WATER OF THE NEW SPRING.	WATER OF THE OLD SPRING.
Carbonat of iron	.75	
Oxyds of iron and mangane ſe -	—	*Too ſmall to be weighed.*
Oxygenated muriat of iron and manganeſe - -	*Unknown, but very ſmall.*	*Unknown, but very ſmall.*
Sulphur - - -	*Unknown, but very ſmall.*	—
Muriat of magneſia	11.5	58
Muriat of ſoda	430	330
Sulphat of ſoda	152	62
Sulphat of lime	112	146

In the courſe of his experiments, for which we muſt refer to the original memoir, in Tranſactions of the Mancheſter Society, Mr Lambe thinks he diſcovered the origin of the *muriatic acid*. He found a coincidence, very unexpected, between the hepatiſed ſolution of iron and the oxygenated muriat of iron. "I had almoſt concluded (ſays he), from the reſemblance between the properties of this ſalt and the phenomena of the water, that the water contains this very ſalt. Now, I conclude, that they contain a matter, be it what it may, produced by the action of hepatic gas on iron. But they are the very ſame facts which form the baſis, upon which each ſeparate inference is built. Does it not follow, then, as a neceſſary conſequence, that the hepatiſed ſolution itſelf contains a muriat of iron highly oxygenated, and that therefore *in this proceſs muriatic acid is generated?* This concluſion ſeemed authoriſed by reaſon, and experiment has confirmed it."

LEMNISCATE, the name of a curve in the form of the figure of 8.

LEMON-juice, is an article of ſuch harmleſs luxury, and in ſome caſes of ſuch real utility, that many of our readers will be pleaſed to know a ſimple method by which they may obtain it in great purity. In the article Chemistry (*Suppl.*), nº 476, we have ſhewn from Scheele and Dizé, how to obtain the citric acid perfectly pure, and in the form of cryſtals; but here we mean nothing more than to ſhew how it may be completely ſeparated from that ſlimy ſubſtance with which it is always mixed in the lemon, without allowing it time to ſpoil or to acquire any diſagreeable taſte during the ſeparation. This we are enabled to do by M. Brugnatelli, who, in the 2d volume of the *Annali di Chimia*, informs us, that he expreſſed in the common manner the juice of perfectly ripe lemons, and ſtrained it through a piece of linen. In half an hour he ſtrained it again, to free it from a little ſlimy matter which had ſettled at the bottom of the veſſel. He then added to the juice a certain quantity of the ſtrongeſt ſpirit of wine, and preſerved the mixture for ſome days in a well-corked bottle. During that time there was a conſiderable depoſit, which to all appearance was of a ſlimy nature, and which he ſeparated by filtering paper. If the fluid was too thick to paſs through the filter, he diluted it again with ſpirit of wine. After this operation, the depoſit remained on the paper, which was entirely covered with it; and he obtained, in the veſſel placed below, the pureſt acid of lemons combined with ſpirit of wine.

If it be required to obtain the acid perfectly pure, nothing is neceſſary but to ſeparate from it the ſpirit of wine, which can be beſt effected by evaporation. The acid of the lemons aſſumes, after it has been freed from the ſpirit of wine and the moiſture combined with it, a yellowiſh colour, and becomes ſo ſtrong, that by its taſte it might be conſidered as a mineral acid.

It is not neceſſary to evaporate the ſpirit of wine in a cloſe veſſel, if the experiment is made only on a ſmall ſcale; nor is there any danger that in open veſſels any of the acid will be loſt, as it is too fixed to be volatiliſed by the ſame degree of heat at which ſpirit of wine evaporates. This acid has peculiar properties, which deſerve farther examination.

LENSES (ſee Lens and Dioptrics, *Encycl.*), are either blown or ground.

Blown Lenses are uſed only in the ſingle microſcope;

and the uſual method of making them has been to draw out a fine thread of the ſoft white glaſs called *cryſtal*, and to convert the extremity of this into a ſpherule by melting it at the flame of a candle. But this glaſs contains lead, which is diſpoſed to become opake by partial reduction, unleſs the management be very carefully attended to. We are informed, however, by Mr Nicholſon, that the hard glaſs uſed for windows ſeldom fails to afford excellent ſpherules. This glaſs is of a clear bright green colour when ſeen edgewiſe. A thin piece was cut from the edge of a pane of glaſs leſs than one-tenth of an inch broad. This was held perpendicularly by the upper end, and the flame of a candle was directed upon it by the blow-pipe at the diſtance of about an inch from the lower end. The glaſs became ſoft, and the lower piece deſcended by its own weight to the diſtance of about two feet, where it remained ſuſpended by a thin thread of glaſs about one five-hundredth of an inch in diameter. A part of this thread was applied endwiſe to the lower blue part of the flame of the candle without the uſe of the blow-pipe. The extremity immediately became white-hot, and formed a globule. The glaſs was then gradually and regularly thruſt towards the flame, but never into it, until the globule was ſufficiently large. A number of theſe were made; and being afterwards examined, by viewing their focal images with a deep magnifier, proved very bright, perfect, and round. This, as the ingenious author obſerves, may prove an acceptable piece of information to thoſe eminent men (and there are many ſuch), whoſe narrow circumſtances, or remote ſituations, are obliged to have recourſe to their own ſkill and ingenuity for experimental implements.

Ground Lenses, are ſuch as are ground or rubbed into the deſired ſhape, and then poliſhed. Different ſhapes have been propoſed for lenſes; but in the article Optics, n° 251 (*Encycl.*), it has been ſhewn that, after all, the ſpherical is the moſt practically uſeful. By many of the methods of grinding, however, the artificer, with his utmoſt care, can only produce an approximation to a truly ſpherical figure; and, indeed, gentlemen have, for the moſt part, nothing to depend on for the ſphericity of the lenſes of their teleſcopes, but the care and integrity of the workmen. In the 41ſt volume of the Tranſactions of the Royal Society of London, a machine is deſcribed by Mr Samuel Jenkins, which, as it is contrived to turn a ſphere at one and the ſame time on two axes, cutting each other at right angles, will produce the ſegment of a true ſphere merely by turning round the wheels, and that without any care or ſkill in the workmen. The following deſcription of this machine will enable our readers fully to comprehend its conſtruction, and the mode of uſing it: A is a globe covered with cement, in which are fixed the pieces of glaſs to be ground. This globe is faſtened to the axis, and turns with the wheel B. C is the braſs cup which poliſhes the glaſs: this is faſtened to the axis, and turns with the wheel D. The motion of the cup C, therefore, is at right angles with the motion of the globe A; whence it follows demonſtrably, that the pieces of glaſs ground by this double motion muſt be formed into the ſegments of ſpheres.

Plate XXXII

LEO X. is a pontiff to whom learning, and art, and ſcience, are ſo deeply indebted, that not to give a ſketch of his life and character, in a Work of this kind, would be an unpardonable omiſſion. A character of him is indeed given in the *Encyclopædia*; but it is ſo far from the truth, that it is difficult to conceive the prejudices under which he muſt have laboured by whom ſuch a libel was drawn up.

Leo, whoſe name, before his elevation to the pontificate, was *Giovanni de Medici*, was the ſecond ſon of Lorenzo de Medici, juſtly ſtyled the Magnificent. In the life of that great man publiſhed in this *Supplement*, the reader will ſee by what means, and for what purpoſe, he got Giovanni raiſed to the dignity of cardinal at ſo early a period of life; and in the elegant work of Roſcoe, to which we there refer, he will find ſuch inſtructions of Lorenzo to the cardinal as muſt have made a deep impreſſion on his youthful mind.

Speaking of his promotion, Lorenzo ſays, "The firſt thing that I would ſuggeſt to you, is, that you ought to be grateful to God, and continually to recollect that it is not through your merits, your prudence, or your ſolicitude, that this event has taken place, but through his favour, which you can repay only by a *pious*, *chaſte*, and *exemplary life*; and that your obligations to the performance of theſe duties are ſo much the greater, as in your *early years* you have given ſome *reaſonable expectation* that your riper age may produce ſuch fruits. It would indeed be highly diſgraceful, and as contrary to your duty as to my *hopes*, if at a time when others diſplay a greater ſhare of reaſon, and adopt a better mode of life, you ſhould forget the *precepts of your youth*, and forſake the path in which you have *hitherto trodden*."—"I well know (continues Lorenzo), that as you are now to reſide at Rome, that ſink of all iniquity, the difficulty of conducting yourſelf by theſe admonitions will be increaſed. The influence of example is itſelf prevalent; but you will probably meet with thoſe, who will particularly endeavour to corrupt and incite you to vice; becauſe, as you yourſelf may perceive, your early attainment of ſo great a dignity is not obſerved without envy, and thoſe who could not prevent your receiving that honour, will ſecretly endeavour to diminiſh it, by inducing you to forfeit the good eſtimation of the public."—"You are not unacquainted with the great importance of the character which you have to ſuſtain; for you well know, that all the Chriſtian world would proſper if the cardinals were what they ought to be; becauſe in ſuch a caſe there would always be a good pope, upon which the tranquillity of Chriſtendom ſo materially depends."

As this was a confidential letter from Lorenzo to his ſon, the firſt of theſe extracts furniſhes very ſufficient evidence, that Giovanni had been at leaſt a well behaved boy, diligent in his ſtudies, and regular in his conduct; and without ſuppoſing him remarkably religious, the admonitions of ſuch a father, aided by his own ambition and love of letters, would ſurely guard him againſt ſuch groſs licentiouſneſs as that of which he is accuſed in the *Encyclopædia*. How much he revered his father, is apparent from the letter which he wrote to his brother immediately after Lorenzo's death. "What a father (ſays he) have we loſt! How indulgent to his children! Wonder not, then, that I grieve, that I lament, that I find no reſt. Yet, my brother, I have ſome conſolation in reflecting that I have thee, whom I ſhall always regard in the place of a father." Surely this is not the language of a groſs ſenſualiſt, or of one who could ſoon forget the ſalutary admonitions of ſuch a parent as Lorenzo de Medici. But it is needleſs to infer the decency of his character by ſuch reaſonings as theſe. The ſtory publiſhed in the *Encyclopedia*, of the manner in which the Cardinal de Medici obtained the tiara, cannot poſſibly be true. The reader, who ſhall turn to the article Pope in that Work, will find that the conclave, when fitted up for an election, is ſo large a place, that we may ſafely affirm, that had the cardinal's ulcer diſcharged matter ſo fetid as to *poiſon all the cells*, the aſſertion of the phyſicians would have been verified, and that in the then ſtate of the healing art, the new pope could not have ſurvived a month. Let it be remembered, too, that Leo, at his acceſſion, was not 30, but 37 years of age, and that he had long ruled in Florence with ſovereign ſway by the ſame means which had upheld the authority of his father. The follies of youth, therefore, had he ever been remarkable for ſuch follies, muſt have been over with him; and in ſuch a ſtate as Florence he could not have maintained the authority of Lorenzo, without exhibiting not only Lorenzo's liberality, but likewiſe his decency of manners.

The next charge brought againſt Leo in the *Encyclopedia* is, that he publiſhed general indulgences throughout Europe; and this is ſo expreſſed as to lead the ill-informed reader to ſuppoſe, either that no ſuch indulgences had ever been publiſhed by any of his predeceſſors, or that there was ſomething peculiarly ſcandalous in Leo's mode of publiſhing them. Both ſuppoſitions, however, are erroneous. The hiſtorian of the council of Trent, who certainly was not partial to the court of Rome, or to the diſpenſing power of the pope, has ſhewn, that the practice of raiſing money by the publication of indulgences, had prevailed ever ſince the year 1100; that many former popes had raiſed money in this manner for purpoſes much leſs laudable than thoſe which Leo had in his eye; and that the real cauſe of Luther's attack upon Leo's indulgences was, that they were preached through Saxony by the Dominican friars; whereas the preaching of former indulgences had been committed to the hermits of St Auguſtine, the order to which Luther himſelf belonged!

Leo is likewiſe accuſed in the *Encyclopedia* of being a profeſſed infidel, and of having called Chriſtianity "a fable very profitable for him and his predeceſſors." But of the truth of this accuſation there ſeems not to be the ſhadow of evidence. Leo had too much ſenſe to utter expreſſions of this kind, even had he been an unbeliever in his heart; for he could not poſſibly expect that his indulgences and pardons would be purchaſed, had he declared in ſuch ſtrong terms that they were of no value. Father Paul indeed ſays, that he was not a deep divine, or ſo pious as ſome of his predeceſſors; but he affirms, that he *adorned the papacy* with many admirable qualities; that he was learned, affable, liberal, *good;* that he delighted in healing differences, and that his equal had not, for many years, filled the chair of St Peter. Surely this is not the character of a profane infidel!

Leo has been charged with raiſing his own family to grandeur at the expence of juſtice; and of dealing treacherouſly, in order to effect this purpoſe, both with the emperor and with the French king. But the charge is either falſe or greatly exaggerated. He loſt no opportunity indeed of aggrandizing his relations, well knowing, that in order to ſecure to them any laſting benefit, it was neceſſary that they ſhould be powerful enough to defend themſelves, after his death, from the rapacious aims of ſucceeding pontiffs; but, in proſecuting this plan, he was ſo far from acting tyrannically or injuriouſly to others, that during his pontificate, the papal dominions enjoyed a degree of tranquillity ſuperior to any other Italian ſtate. During the conteſts that took place between the emperor and the French king, ſo far from acting treacherouſly, he diſtinguiſhed himſelf by his moderation, his vigilance, and his political addreſs; on which account he is juſtly celebrated by an eminent hiſtorian of our own *, as "the only prince of the age who obſerved the motions of the two contending monarchs with a prudent attention, or who diſcovered a proper ſolicitude for the public ſafety."

We truſt that no zealous Proteſtant will think we have employed our time ill, in vindicating the character of this ſplendid pontiff; for good learning, and, of courſe, true religion, are more indebted to Leo X. than to any other individual of the age in which he lived, his father Lorenzo alone excepted.

Leo Minor, the *Little Lion*, a conſtellation of the northern hemiſphere, and one of the new ones that were formed out of what were left by the ancients, under the name of *Stellæ Informes*, or unformed ſtars. See Astronomy, nº 406, *Encycl.*

LESLIE (Charles), was a man ſo eminent for his learning, his talents, and his piety, that a fuller account of him than that which is given in the *Encyclopedia* muſt be acceptable to our Chriſtian readers. He was the ſecond ſon of Dr John Leſlie biſhop of Clogher in Ireland, who was deſcended from an ancient family in the north of Scotland, and being an admirable ſcholar, roſe to the dignity of biſhop of Orkney in his own country, whence he was tranſlated, in 1633, to Raphoe in Ireland, and afterwards, in 1661, to the ſee of Clogher.

Our author was born in Ireland, but in what year we have not learned. A ludicrous ſtory goes indeed of his having been begotten in priſon, and of his father having ſaid that he hoped he would in conſequence become the greateſt ſcourge of the covenanters that Great Britain or Ireland had ever ſeen. This ſtory, with all its circumſtances as told to us, can hardly be true; but we think it could not have been fabricated, had not Charles Leſlie been born within a year of Cromwell's conqueſt of Ireland, when the good biſhop, having ſuſtained a ſiege in his caſtle of Raphoe againſt that arch rebel, was ſome time kept in cloſe confinement.

We are equally ignorant of the ſchool where he was educated as of the year of his birth; but we know that he had his academical education in Trinity College, Dublin, where he took the degree of maſter of arts. In the year 1671, he loſt his father, when he came over to England, and, entering himſelf in the temple, ſtudied law for ſome years, but afterwards relinquiſhed it for the ſtudy of divinity. In 1680, he was admitted into holy orders; and, in 1687, was made chancellor of Connor.

About this period he rendered himſelf particularly obnoxious to the Popiſh party in Ireland, by his zealous oppoſition to them, which was thus called forth. Roger Boyle, biſhop of Clogher, dying in 1687, Patrick Tyrrel was made titular Popiſh biſhop, and had the revenues of the ſee aſſigned him by king James. He ſet

Biographical Dictionary.

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* Dr Robertſon.

up a convent of friars in Monaghan: and, fixing his habitation there, held a public viſitation of his clergy with great ſolemnity; when, ſome ſubtle logicians attending him, he was ſo inſolent as to challenge the Proteſtant clergy to a public diſputation. Leſlie undertook the taſk, and performed it to the ſatisfaction of the Proteſtants; though it happened, as it generally does at ſuch conteſts, that both ſides claimed the victory. He afterwards held another public diſputation with two celebrated Popiſh divines, in the church of Tynan, in the dioceſe of Armagh, before a very numerous aſſembly of perſons of both religions; the iſſue of which was, that Mr John Stewart, a Popiſh gentleman, ſolemnly renounced the errors of the church of Rome.

As the Papiſts had got poſſeſſion of an Epiſcopal ſee, they engroſſed other offices too; and a Popiſh high-ſheriff was appointed for the county of Monaghan. This proceeding alarmed the gentlemen in that county; who, depending much on Leſlie's knowledge as a juſtice of peace, repaired to him, then confined, by the gout, to his houſe. He told them, that it would be as illegal in them to permit the ſheriff to act as it would be in him to attempt it. But they inſiſting that he ſhould appear himſelf on the bench at the next quarter-ſeſſions, and all promiſing to ſtand by him, he was carried thither with much difficulty and in great pain. When the ſheriff appeared, and was taking his place, he was aſked whether he was legally qualified; to which he anſwered pertly, "That he was of the king's own religion, and it was his majeſty's will that he ſhould be ſheriff." Leſlie replied, "That they were not inquiring into his majeſty's religion, but whether he (the pretended ſheriff) had qualified himſelf according to law, for acting as a proper officer; that the law was the king's will, and nothing elſe to be deemed ſuch; that his ſubjects had no other way of knowing his will, but as it is revealed to them in his laws: and it muſt always be thought to continue ſo, till the contrary is notified to them in the ſame authentic manner." Upon this, the bench unanimouſly agreed to commit the pretended ſheriff, for his intruſion and arrogant contempt of the court. Leſlie alſo committed ſome officers of that tumultuous army which the Lord Tyrconnel raiſed for robbing the country.

In this ſpirited conduct Leſlie acted like a ſound divine and an upright magiſtrate; but though he thought himſelf authoriſed to reſiſt the illegal mandates of his ſovereign, like many other great and good men, he diſtinguiſhed between active and paſſive obedience, and felt not himſelf at liberty to transfer his allegiance from that ſovereign to another. Refuſing therefore to take the oaths to king William and queen Mary, he was deprived of all his preferments; and in 1689 he removed with his family to England, where he publiſhed the following works, beſides thoſe already noticed in the *Encyclopædia:* 1. Anſwer to Archbiſhop King's State of the Proteſtants in Ireland. 2. Caſſandra, concerning the new Aſſociations, &c. 1703, 4to. 3. Rehearſals; at firſt a weekly paper, publiſhed afterwards twice a-week in a half-ſheet, by way of dialogue on the affairs of the times; begun in 1704, and continued for ſix or ſeven years. 4. The Wolf ſtripped of his Shepherd's Clothing, in Anſwer to Moderation a Virtue, 1704, 4to. The pamphlet it anſwers was written by James Owen. 5. The Biſhop of Sarum's [Burnet's] proper Defence, from a Speech ſaid to be ſpoken by him againſt occaſional conformity, 1704, 4to. 6. The new Aſſociation of thoſe called Moderate Churchmen, &c. occaſioned by a pamphlet, intitled, The Danger of Prieſtcraft, 1705, 4to. 7. The new Aſſociation, part 2d, 1705, 4to. 8. The Principles of Diſſenters concerning Toleration and occaſional Conformity, 1705, 4to. 9. A Warning for the Church of England, 1706, 4to. Some have doubted whether theſe two pieces were his. 10. The good old Cauſe, or Lying in Truth; being a ſecond Defence of the Biſhop of Sarum from a ſecond Speech, &c. 1710. For this a warrant was iſſued out againſt Leſlie. 11. A Letter to the Biſhop of Sarum, in Anſwer to his Sermon after the Queen's Death, in Defence of the Revolution, 1715. 12. Salt for the Leech. 13. The Anatomy of a Jacobite. 14. Gallienus redivivus. 15. Delenda Carthago. 16 A Letter to Mr William Molyneux, on his Caſe of Ireland's being bound by the Engliſh Acts of Parliament. 17. A Letter to Julian Johnſon. 18. Several Tracts againſt Dr Higden and Mr Hoadly. 19. A Diſcourſe, ſhewing who they are that are now qualified to adminiſter Baptiſm. 20. The Hiſtory of Sin and Hereſy, &c. 1698, 8vo. 21. The Truth of Chriſtianity demonſtrated, in a Dialogue between a Chriſtian and a Deiſt, 1711, 8vo.—Againſt the Papiſts: 22. Of private Judgment and Authority in Matters of Faith. 23. The Caſe ſtated between the Church of Rome and the Church of England, &c. 1713. 24. The true notion of the Catholic Church, in Anſwer to the Biſhop of Meaux's Letter to Mr Nelſon, &c.

Beſides theſe, he publiſhed the four following tracts: 25. A Sermon preached in Cheſter, againſt Marriages in different Communions, 1702, 8vo. This ſermon occaſioned Mr Dodwell's diſcourſe upon the ſame ſubject. 26. A Diſſertation concerning the Uſe and Authority of Eccleſiaſtical Hiſtory. 27. The Caſe of the Regal and the Pontificate. 28. A Supplement, in Anſwer to a Book, intitled, The regal Supremacy in Eccleſiaſtical Affairs aſſerted, &c. Theſe two laſt pieces were occaſioned by the diſpute about the rights of convocation, between Wake, &c. on one ſide, and Atterbury and his friends, among whom was Leſlie, on the other.

It is ſaid by the authors of the Biographical Dictionary, that, in conſequence of a publication of his, intitled, "The hereditary right of the crown of England aſſerted," he was under the neceſſity of leaving the kingdom; and that he repaired to the Pretender at *Bar le duc*, where he was allowed to officiate, in a private chapel, after the rites of the church of England; and where he endeavoured, though in vain, to convert the Pretender to the Proteſtant religion.

That he repaired to *Bar le duc*, and endeavoured to convert to the church of England him whom he conſidered as the rightful ſovereign of England, is indeed true; but we have reaſon to believe that this was not in conſequence of his being obliged to leave the kingdom. There is, in the firſt place, ſome grounds to believe, that "The hereditary right of the crown of England aſſerted" was not written by him; and there is ſtill in exiſtence undoubted evidence, that, in conſequence of his great fame as a polemic, he was ſent to *Bar le duc* for the expreſs purpoſe of endeavouring to convert the ſon of James II. by ſome gentlemen of fortune in England, who wiſhed to ſee that prince on the throne of his anceſtors. The writer of this article had the honour, 16 or 17 years ago, to be known to the granddaughter of one of thoſe gentlemen—a lady of the ſtricteſt veracity; and from her he received many anecdotes of Leſlie and his aſſociates, which, as he did not then foreſee that he ſhould have the preſent occaſion for them, he has ſuffered to ſlip from his memory. That lady is ſtill alive, and we have reaſon to believe is in poſſeſſion of many letters by Leſlie, written in confidence to her grandfather, both from *Bar le duc* and from St Germains; and by the account which ſhe gave of theſe letters, Leſlie appears to have conſidered his prince as a weak and incorrigible bigot, though, in every thing but religion, an amiable and accompliſhed man. This may have been his genuine character; for we all know that it was the character of his father; but it is not of him that we are writing.

Mr Leſlie having remained abroad from the year 1709 till 1721, returned that year to England, reſolving, whatever the conſequences might be, to die in his own country. Some of his friends acquainting lord Sunderland with his purpoſes, implored his protection for the good old man, which his lordſhip readily and generouſly promiſed. Mr Leſlie had no ſooner arrived in London, than a member of the houſe of commons officiouſly waited on lord Sunderland with the news, but met with ſuch a reception from his lordſhip as the malice of his errand deſerved. Our author then went over to Ireland, where he died April 13. 1722. at his own houſe at Glaſlough in the county of Monaghan.

His character may be ſummed up in a few words. Conſummate learning, attended by the loweſt humility, the ſtricteſt piety without the leaſt tincture of moroſeneſs, a converſation to the laſt degree lively and ſpirited, yet to the laſt degree innocent, made him the delight of mankind, and leaves what Dr Hickes ſays of him unqueſtionable, that he made more converts to a ſound faith and holy life than any other man of our times.

A charge, however, has been lately brought againſt him of ſuch a nature, as, if well founded, muſt detract not only from his literary fame, but alſo from his integrity. "The ſhort and eaſy Method with the Deiſts" is unqueſtionably his moſt valuable, and apparently his moſt original work; yet this tract is publiſhed in French among the works of the Abbé St Real, who died in 1692; and therefore it has been ſaid, that unleſs it was publiſhed in Engliſh prior to that period, Charles Leſlie muſt be conſidered as a ſhameleſs plagiary.

The Engliſh work was certainly not publiſhed prior to the death of Abbé St Real; for the firſt edition bears date July 17th 1697; and yet many reaſons conſpire to convince us that our countryman was no plagiary. There is indeed a ſtriking ſimilarity between the Engliſh and the French works; but this is no complete proof that the one was copied from the other. The article PHILOLOGY in the *Encyclopædia Britannica*, of which Dr Doig is the author, was publiſhed the very ſame week with Dr Vincent's diſſertation on the Greek verb. It was therefore impoſſible that either of theſe learned men, who were till then ſtrangers to each others names, could have ſtolen aught from the other; and yet Dr Vincent's derivation of the Greek verb bears as ſtriking a reſemblance to Dr Doig's as the Abbé St Real's work does to Charles Leſlie's. In the article MIRACLE (*Encycl.*), the credibility of the goſpel miracles is eſtabliſhed by an argument, which the author certainly borrowed from no man, and which the late principal Campbell conſidered as original; yet within half a year of the publication of that article, the credibility of the goſpel-miracles was treated in the very ſame manner by F. SAYERS, M. D. though there is in his diſſertation complete internal evidence that he had not ſeen the article in the *Encyclopædia*. Not many months ago, the author of this ſketch reviewed, in one of the journals, the work of a friend, which was at the ſame time reviewed in another journal, that at this moment he has never ſeen. Yet he has been told by a friend, who is much verſant in that kind of reading, and knows nothing of his concern with either review, that the book in queſtion muſt, in both journals, have been reviewed by the ſame hand; becauſe in both the ſame character is given of it in almoſt the very ſame words!

After theſe inſtances of apparent plagiariſm, which we know to be *only* apparent, has any man a right to ſay that Charles Leſlie and the Abbé St Real might not have have treated their ſubject in the way that they have done, without either borrowing from the other? The coincidence of arrangement and reaſoning in the two works is indeed very ſurpriſing; but it is by no means ſo ſurpriſing as the coincidence of etymological deductions which appears in the works of the Doctors Doig and Vincent. The divines reaſon from the acknowledged laws of human thought; the reaſonings of the grammarians, with all due deference to their ſuperior learning, we cannot help conſidering as ſometimes fanciful.

But this is not all that we have to urge on the ſubject. If there be plagiariſm in the caſe, and the identity of titles looks very like it, it is infinitely more probable that the editor of St Real's works ſtole from Leſlie, than that Leſlie ſtole from St Real, unleſs it can be proved that the works of the Abbé, and this work in particular, were publiſhed before the year 1697. At that period, the Engliſh language was very little read or underſtood on the continent; whilſt in Britain the French language was, by *ſcholars*, as generally underſtood as at preſent. Hence it is, that ſo many Frenchmen, and indeed foreigners of different nations, thought themſelves ſafe in pilfering ſcience from the Britiſh philoſophers *; whilſt there is not, that we know, one well authenticated inſtance of a Britiſh philoſopher appropriating to himſelf the diſcoveries of a foreigner. If, then, ſuch men as LEIBNITZ, John BERNOULLI, and DES CARTES, truſting to the improbability of detection, condeſcended to pilfer the diſcoveries of HOOKE, NEWTON, and HARRIOT, is it improbable that the editor of the works of St Real would claim to his friend a celebrated tract, of which he knew the real author to be obnoxious to the government of his own country, and therefore not likely to have powerful friends to maintain his right?

But farther, Burnet, biſhop of Sarum, was an excellent ſcholar, and well read, as every one knows, in the works of foreign divines. Is it conceivable, that this prelate, when ſmarting under the laſh of Leſlie, would have let ſlip ſo good an opportunity of covering with diſgrace his moſt formidable antagoniſt, had he known that antagoniſt to be guilty of plagiariſm from the writings of the Abbé St Real? Let it be granted, however, that Burnet was a ſtranger to theſe writings and to this plagiariſm; it can hardly be ſuppoſed that *Le Clarc* was a ſtranger to them likewiſe. Yet this author, when, for reaſons beſt known to himſelf, he choſe (1706) to depreciate the argument of *the ſhort method*, and to traduce its author as ignorant of ancient hiſtory, and as having brought forward his four marks for no other purpoſe than to put the deceitful traditions of Popery on the ſame footing with the moſt authentic doctrines of the goſpel, does not ſo much as inſinuate that he borrowed theſe marks from a Popiſh abbé, though ſuch a charge, could he have eſtabliſhed it, would have ſerved his purpoſe more than all his rude railings and invective. But there was no room for ſuch a charge. In the ſecond volume of the works of St Real, publiſhed in 1757, there is indeed a tract entitled *Methode Courte et Aiſée pour combattre les Deiſtes;* and there can be little doubt but that the publiſher wiſhed it to be conſidered as the work of his countryman. Unfortunately, however, for his deſign, a catalogue of the Abbé's works is given in the firſt volume; and in that catalogue the *Methode Courte et Aiſée* is not mentioned.

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* See *Quantity* (Encycl.), *Aſtronomy*, *Dynamics*, *Impulſion*, and *Harriot*, in this Suppl.

We have dwelt thus long on *The Short and Eaſy Method with the Deiſts*, becauſe it is one of the ableſt works that ever was written in proof of the Divine origin of the Jewiſh and Chriſtian Scriptures; a work of which the merit is acknowledged by Lord Bolingbroke, and which, as has been obſerved elſewhere (ſee THEOLOGY, nº 16. *Encycl.*) Dr Conyers Middleton confeſſes to be unanſwerable. If by men of ſcience we be thought to have ſpent our time well in vindicating the rights of our illuſtrious philoſophers Hooke and Newton, to diſcoveries which have been unjuſtly claimed by the philoſophers of Germany and France; we will not ſurely by the friends of Chriſtianity be thought to have employed our time ill in vindicating Leſlie's claim to this deciſive argument in ſupport of our holy religion.

LEVER, the firſt of the mechanical powers, for the properties of which ſee MECHANICS; and for a demonſtration of its fundamental property, ſee STEEL YARD, both in the *Encyclopædia*.

LICENSER OF BOOKS (ſee LIBERTY *of the Preſs, Encycl.*), has been an officer in almoſt every civilized nation, till the end of the laſt century that the office was aboliſhed in Great Britain. Profeſſor Beckmann, with his uſual induſtry *, has proved that ſuch an office was eſtabliſhed not only in the Roman Empire, but even in the republic, and in the free ſtates of ancient Greece. At Athens, the works of Protagoras were prohibited; and all the copies of them which could be collected were burnt by the public crier. At Rome, the writings of Numa, which had been found in his grave, were, by order of the ſenate, condemned to the fire, becauſe they were contrary to the religion which he had introduced. As the populace at Rome were, in times of public calamity, more addicted to ſuperſtition than ſeemed proper to the government, an order was iſſued, that all ſuperſtitious and aſtrological books ſhould be delivered into the hands of the prætor. This order was often repeated; and the emperor Auguſtus cauſed more than twenty thouſand of theſe books to be burnt at one time. Under the ſame emperor the ſatirical works of Labienus were condemned to the fire, which was the firſt inſtance of this nature; and it is related as ſomething ſingular, that, a few years after, the writings of the perſon who had been the cauſe of the order for that purpoſe ſhared the like fate, and were alſo publicly burnt. When Cremutius Cordus, in his hiſtory, called C. Caſſius the laſt of the Romans, the ſenate, in order to flatter Tiberius, cauſed the book to be burnt; but a number of copies were ſaved by being concealed. Antiochus Epiphanes cauſed the books of the Jews to be burnt; and in the firſt centuries of our æra the books of the Chriſtians were treated with equal ſeverity, of which Arnobius bitterly complains. We are told by Euſebius, that Diocleſian cauſed the ſacred Scriptures to be burnt. After the ſpreading of the Chriſtian religion the clergy exerciſed, againſt books that were either unfavourable or diſagreeable to them, the ſame ſeverity which they had cenſured in the heathens as fooliſh and prejudicial to their own cauſe.

Soon after the invention of printing, laws began to be made for ſubjecting books to examination; a regulation propoſed even by Plato; and which has been wiſhed for by many ſince. Our author gives a great deal of curious information on this important ſubject, which our limits do not permit us to repeat; but it is apparent from his work, that the liberty of the preſs is but a modern privilege; and that it has not been enjoyed completely in any country but this happy iſland.

LICHEN (ſee *Encycl.*), is a genus of plants, of which the moſt valuable ſpecies ſeems to be the LICHEN ROCELLA, or *Argol*. As that ſpecies has not been noticed in the article referred to, the following account of it from Profeſſor Beckmann will be acceptable to many of our readers:

It is found in abundance in ſome of the iſlands near the African coaſt, particularly in the Canaries, and in ſeveral of the iſlands in the Archipelago. It grows upright, partly in ſingle, partly in double ſtems, which are about two inches in height. When it is old, theſe ſtems are crowned with a button ſometimes round, and ſometimes of a flat form, which Tournefort, very properly, compares to the excreſcences on the arms of the ſepia. Its colour is ſometimes a light, and ſometimes a dark grey. Of this moſs, with lime, urine, and alkaline ſalts, is formed a dark red paſte, which in commerce has the ſame name, and which is much uſed in dyeing. That well-known ſubſtance called lacmus is alſo made of it.

Theophraſtus, Dioſcorides, and their tranſcriber Pliny, give the name of *Phycos thalaſſion*, or *pontion*, to this plant, which, notwithſtanding its name, is not a ſea weed but a moſs; as it grew on the rocks of different iſlands, and particularly on thoſe of Crete or Candia. It had, in their time, been long uſed for dyeing wool, and the colour it gave when freſh was ſo beautiful, that it excelled the ancient purple, which was not red, as many ſuppoſe, but violet. Pliny tells us, that with this moſs dyers gave the ground or firſt tint to thoſe cloths which they intended to dye with the coſtly purple. When it was firſt employed as a dye by the moderns, is not ſo certain; though the Profeſſor has proved, we think completely, that it muſt have been at leaſt as early as the beginning of the 14th century.

“ Among the oldeſt and principal Florentine families (ſays he), is that known under the name of the

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* *Hiſtory of Inventions*, vol 3.

Oricellarii or Rucellarii, Ruſcellai or Rucellai, ſeveral of whom have diſtinguiſhed themſelves as ſtateſmen and men of letters. This family are deſcended from a German nobleman, named Ferro or Frederigo, who lived in the beginning of the twelfth century. One of his deſcendants, in the year 1300, carried on a great trade in the Levant, by which he acquired conſiderable riches, and returning at length to Florence, with his fortune, firſt made known in Europe the art of dyeing with argol. It is ſaid, that a little before his return from the Levant, happening to make water on a rock covered with this moſs, he obſerved, that the plant, which was there called *reſpio*, or *reſpo*, and in Spain *orciglia*, acquired by the urine a purple, or, as others ſay, a red colour. He therefore tried ſeveral experiments; and when he had brought to perfection the art of dyeing wool with this plant, he made it known at Florence, where he alone practiſed it for a conſiderable time, to the great benefit of the ſtate. From this uſeful invention, the family received the name of Oricellarii, from which, at laſt, was formed Rucellai." The Profeſſor, however, does not believe that this Florentine diſcovered the dye by means of the above-mentioned accident, but that he learned the art in the Levant, and on his return taught it to his countrymen.

"Our dyers do not purchaſe raw argol, but a paſte made of it, which the French call *orſeille en pâte*. The preparation of it was for a long time kept a ſecret by the Florentines. The perſon who, as far as I know, made it firſt known was Roſetti; who, as he himſelf tells us, carried on the trade of dyer at Florence. Some information was afterwards publiſhed concerning it by Imperati * and Micheli the botaniſt †. In later times this art has been much practiſed in France, England, and Holland. Many druggiſts, inſtead of keeping this paſte in a moiſt ſtate with urine, as they ought, ſuffer it to dry, in order to ſave a little dirty work. It then has the appearance of a dark violet-coloured earth, with here and there ſome white ſpots in it.

"The Dutch (continues our author), who have found out better methods than other nations of manufacturing many commodities, ſo as to render them cheaper, and thereby to hurt the trade of their neighbours, are the inventors alſo of lacmus, a preparation of argol, called *orſeille en pierre*, which has greatly leſſened the uſe of that *en pâte*, as it is more eaſily tranſported and preſerved, and fitter for uſe; and as it is beſides, if not cheaper, at leaſt not dearer. This art conſiſts, undoubtedly, in mixing with that commodity ſome leſs valuable ſubſtance, which either improves or does not much impair its quality, and which, at the ſame time, increaſes its weight (A). Thus do they pound cinnabar and ſmalt finer than other nations, and yet ſell both theſe articles cheaper. Thus do they ſift cochineal, and ſell it cheaper than what is unſifted.

"It was for a long time believed, that the Dutch prepared their lacmus from thoſe linen rags which in the ſouth of France are dipped in the juice of the *croton tinctorium*; but at preſent, it is almoſt certainly known, that *orſeille en pâte* is the principal ingredient in *orſeille en pierre* that is in lacmus; and for this curious information we are indebted to Ferber. But whence ariſes the ſmell of the lacmus, which appears ſo like that of the Florentine iris?" Some of the latter may, perhaps, be mixed with it; for our author thinks, that he has obſerved in it ſmall indiſſoluble particles, which may have been bits of the roots. The addition of this ſubſtance can be of no uſe to improve the dye; but it may increaſe the weight, and give the lack more body; and perhaps it may be employed to render imperceptible ſome unpleaſant ſmell, for which purpoſe the roots of that plant are uſed on many other occaſions.

LIGHT, it has been obſerved in the article CHEMISTRY, n° 319. (*Suppl.*), conſiſts of rays differently flexible. This was eſtabliſhed by ſome well deviſed experiments made by Henry Brougham, Eſq; of which it may be proper to give an account here.

In the firſt experiment, he darkened his chamber in the uſual way, and let a beam of the ſun's light into it through the hole of a metal plate fixed in the ſhutter of the window, $\frac{1}{20}$th of an inch in diameter. At the hole within the room he placed a priſm of glaſs, of which the refracting angle was 45 degrees, and which was everywhere covered with black paper, except a ſmall part on each ſide; and through this part the light was refracted ſo as to form a diſtinct ſpectrum on a chart at ſix feet diſtance from the window. In the rays, at two feet from the priſm, he placed a black unpoliſhed pin, of which the diameter was $\frac{1}{10}$th of an inch, parallel to the chart, and in a vertical poſition. The ſhadow of the pin was found in the ſpectrum; and this ſhadow had a conſiderable penumbra, which was broadeſt and moſt diſtinct in the violet part, narroweſt and moſt confuſed in the red, and of an intermediate thickneſs and diſtinctneſs in the intermediate colours. The penumbra was bounded by curvilinear ſides, convex towards the axis to which they approached as to an aſymptote, ſo as to be neareſt to it in the place of the leaſt refrangible rays. By moving the priſm on its axis, and cauſing the colours to aſcend and deſcend on any bodies that were uſed inſtead of the pin, the red, wherever they fell, made the leaſt, and the violet the greateſt, ſhadow.

In the next experiment, a ſcreen was ſubſtituted in the place of the pin; and this ſcreen had a large hole, on which was a braſs plate, pierced with a ſmall hole $\frac{1}{21}$d of an inch in diameter. While an aſſiſtant moved the priſm ſlowly on its axis, the author obſerved the round image made by the different rays paſſing through the hole to the chart; that made by the red was greateſt, that of the violet leaſt, and that of each intermediate rays was of an intermediate ſize. When the ſharp blade of a knife was held at the back of the hole, "ſo as to produce the fringes mentioned by Grimaldo and Newton, theſe fringes in the red were broadeſt and moſt moved inwards to the ſhadow, and moſt dilated when the knife was moved over the hole; and the hole itſelf on the chart was more dilated during the motion when illuminated by the red than when illuminated by any other of the rays, and leaſt of all when illuminated by the violet."

From theſe two experiments, the author infers "that the rays of the ſun's light differ in degree of flexibility, and

* Lib. xxvii c. 9.
† *Novæ Plantarum genera Florentiæ*, 1729.

(A) As dry lacmus is much cheaper than moiſt, it may be readily ſuppoſed that it is adulterated with ſand and other ſubſtances. *Valentini Hiſtoria ſimplicium.* Francf. ad Moen. 1716. fol. p. 152.

and that thoſe which are leaſt *refrangible* are *moſt inflexible.*" From other experiments, he concludes, that the *moſt inflexible* rays are alſo *moſt deflexible.* In the ſequel of his paper, he aſcertains the proportion which the angle of *inflection* bears to that of *deflection* at equal incidences, and the proportion which the different *flexibilities* of the different rays bear to one another. We ſhall give an account of ſome other experiments made by him, and of the inferences drawn from them, under the word Reflexity, to which a reference has already been made.

LIMBERS, in artillery, a ſort of advanced train, joined to the carriage of a cannon on a march. It is compoſed of two ſhafts, wide enough to receive a horſe between them, called the *fillet horſe:* theſe ſhafts are joined by two bars of wood, and a bolt of iron at one end, and mounted on a pair of rather ſmall wheels. Upon the axle-tree riſes a ſtrong iron ſpike, which is put into a hole in the hinder part of the train of the gun-carriage, to draw it by. But when a gun is in action, the limbers are taken off, and run out behind it.

LIMIT of a Planet, has been ſometimes uſed for its greateſt heliocentric latitude.

Limited Problem, denotes a problem that has but one ſolution, or ſome determinate number of ſolutions: as to deſcribe a circle through three given points that do not lie in a right line, which is limited to one ſolution only; to divide a parallelogram into two equal parts by a line parallel to one ſide, which admits of two ſolutions, according as the line is parallel to the length or breadth of the parallelogram; or to divide a triangle in any ratio by a line parallel to one ſide, which is limited to three ſolutions, as the line may be parallel to any of the three ſides.

LOCAL Problem, is one that is capable of an infinite number of different ſolutions; becauſe the point, which is to ſolve the problem, may be indifferently taken within a certain extent; as ſuppoſe any where in ſuch a line, within ſuch a plane figure, &c. which is called a *geometrical Locus*.

A local problem is *ſimple*, when the point ſought is in a right line; *plane*, when the point ſought is in the circumference of a circle; *ſolid*, when it is in the circumference of a conic ſection; or *ſurſolid*, when the point is in the perimeter of a line of a higher kind.

LOCI, the plural of

LOCUS, a line by which a local or indeterminate problem is ſolved; or a line of which any point may equally ſolve an indeterminate problem. See Algebra, *Encycl.*

LOGISTIC Curve, the ſame with *Logarithmic Curve*, for which ſee *Encycl.*

LOGISTICS, or *Logistical Arithmetic*, a name ſometimes employed for the arithmetic of ſexageſimal fractions, uſed in aſtronomical computations.

The ſame term has been uſed for the rules of computations in algebra, and in other ſpecies of arithmetic: witneſs the logiſtics of Vieta and other writers.

Shakerly, in his *Tabulæ Britannicæ*, has a table of logarithms adapted to ſexageſimal fractions, and which he calls Logiſtical Logarithms; and the expeditious arithmetic, obtained by means of them, he calls Logiſtical Arithmetic.

Libyan LOTUS has been deſcribed (*Encycl.*) under the title Rhamnus; but the following additional particulars from Mr Park will be acceptable to our botanical readers:

The lotus is very common in all the countries which our author viſited, and he had an opportunity to make a drawing of a branch in flower, of which an engraving is publiſhed in his travels, that with his permiſſion we have copied (ſee Plate XXX.). The lotus produces fruit which the negroes call *tomberongs*. Theſe are ſmall farinaceous berries, of a yellow colour and delicious taſte. They are much eſteemed by the natives, who convert them into a ſort of bread, by expoſing them for ſome days to the ſun, and afterwards pounding them gently in a wooden mortar, until the farinaceous part of the berry is ſeparated from the ſtone. This meal is then mixed with a little water, and formed into cakes; which, when dried in the ſun, reſemble in colour and flavour the ſweeteſt gingerbread. The ſtones are afterwards put into a veſſel of water, and ſhaken about ſo as to ſeparate the meal which may ſtill adhere to them: this communicates a ſweet and agreeable taſte to the water, and with the addition of a little pounded millet, forms a pleaſant gruel called *fondi*, which is the common breakfaſt in many parts of Ludamar, during the months of February and March. The fruit is collected by ſpreading a cloth upon the ground, and beating the branches with a ſtick. Our author thinks there can be little doubt of this being the lotus mentioned by Pliny, as the food of the Lybian Lotophagi. An army may very well have been fed with the bread made of the meal of the fruit, as is ſaid by Pliny to have been done in Lybia; and as the taſte of the bread is ſweet and agreeable, it is not likely that the ſoldiers would complain of it,

LOWANG, a Chineſe iſland of ſome extent in the neighbourhood of the Chusan-Iſles, which ſee in this *Supplement*. Some of the gentlemen belonging to the Britiſh embaſſy went aſhore on Lowang, which they deſcribed as naked both of trees and of cattle. They examined particularly a ſmall level plain recovered from the ſea, which was kept out by an embankment of earth, at leaſt thirty feet thick. The quantity of ground gained by it ſeemed ſcarcely to be worth the labour that it muſt have coſt. The plain was indeed cultivated with the utmoſt care, and laid out chiefly in rice-plats, ſupplied with water collected from the adjacent hills into little channels, through which it was conveyed to every part of thoſe plantations. It was manured, inſtead of the dung of animals, with matters more offenſive to the human ſenſes, and which are not very generally applied to the purpoſes of agriculture in England. Earthen veſſels were ſunk into the ground for the reception of ſuch manure; and for containing liquids of an analogous nature, in which the grain was ſteeped previouſly to its being ſown; an operation which is ſuppoſed to haſten the growth of the future plant, as well as to prevent any injury from inſects in its tender ſtate.

The party fell in with a peaſant who, though ſtruck with their appearance, was not ſo ſcared by it as to ſhun them. He was dreſſed in looſe garments of blue cotton, a ſtraw hat upon his head faſtened by a ſtring under his chin, and half boots upon his legs. He ſeemed to enter into the ſpirit of curioſity, naturally animating travellers, and readily led them towards an adjoining village. Paſſing by a ſmall farm houſe, they were invited into it by the tenant, who, together with his ſon, obſerved them with aſtoniſhed eyes. The houſe was built of wood, the uprights of the natural form of the timber. No ceiling concealed the inſide of the roof, which was put together ſtrongly, and covered with the ſtraw of rice. The floor was of earth beaten hard, and the partitions between the rooms conſiſted of mats hanging from the beams. Two ſpinning wheels for cotton were ſeen in the outer room; but the ſeats for the ſpinners were empty. They had probably been filled by females, who retired on the approach of ſtrangers; while they remained, none of that ſex appeared. Round the houſe were planted cluſters of bamboo, and of that ſpecies of palm, of which each leaf reſembles the form of a fan; and, uſed as ſuch, becomes an article of merchandize.

LOXODROMIC Curve, or *Spiral*, is the ſame as the rhumb line, or path of a ſhip ſailing always on the ſame courſe in an oblique direction, or making always the ſame angle with every meridian. It is a ſpecies of logarithmic ſpiral, deſcribed on the ſurface of the ſphere, having the meridians for its radii.

LOXODROMICS, the art or method of oblique ſailing, by the loxodromic or rhumb line.

LUCIOLE, a name given in the *Annales de Chimie* to the *Lampyris Italica* (See Lampyris, *Encycl.*). According to Dr Carradori, the light of the luciole does not depend on the influence of any external cauſe, but merely on the will of thoſe inſects. While they fly about at freedom, their ſhining is very regular; but when they are once in our power, they ſhine very irregularly, or do not ſhine at all. When they are moleſted, they emit a frequent light, which appears to be a mark of their reſentment. When placed on their backs, they ſhine almoſt without interruption, making continual efforts to turn themſelves from that poſition. In the daytime it is neceſſary to torment them in order to make them ſhine; and thence it follows, that the day to them is the ſeaſon of repoſe. The luciole emit light at pleaſure from every point of their bellies, which proves that they can move all the parts of their viſcera independently of each other. They can alſo render their phoſphoreſcence more or leſs vivid, and continue it as long as they pleaſe.

A ſlight compreſſion deprives the luciole of their power of ceaſing to ſhine. The author is inclined to believe, that the movement by which they conceal their light is executed by drawing back their phoſphoric ſubſtance into a particular membrane or tunic. He ſuppoſes alſo, that the ſparkling conſiſts in a trembling or oſcillation of the phoſphoric maſs. He is of opinion, that there is no emanation of a phoſphoric ſubſtance, and that the whole phenomenon takes place in the interior part of the luminous viſcera. When the ſhining is at its greateſt degree of height, it is ſo ſtrong that a perſon may by it eaſily diſtinguiſh the hours on the ſmalleſt watch, and the letters of any type whatever.

The phoſphoric part of the luciole does not extend farther than to the extreme rings of the belly. It is there incloſed in a covering compoſed of two portions of membranes, one of which forms the upper, and the other the lower, part of the belly, and which are joined together. Behind this receptacle is placed the phoſphorus, which reſembles a paſte, having the ſmell of garlic, and very little taſte. The phoſphoric matter iſſues from a ſort of bag on the ſlighteſt preſſure; when ſqueezed out, this matter loſes its ſplendour in a few hours, and is converted into a white dry ſubſtance. A portion of the phoſphoric belly put into oil, ſhone only with a feeble light, and was ſoon extinguiſhed. In water, a like portion ſhone with the ſame vivacity as in the air, and for a much longer time. The author thence concludes, that the phoſphoreſcence of the luciole is not the effect of ſlow inflammation, nor of the fixation of azotic gas, as the oil in which they ſhine does not contain a ſingle air-bubble: beſides, the phoſphorus of theſe inſects ſhines in a barometrical vacuum. The obſervation made by Foſter, that the luciole diffuſed a more vivid light in oxygen gas than in atmoſpheric air, does not, according to Carradori, depend upon a combuſtion more animated by the inſpiration of this gas, but on the animals feeling themſelves, while in that gas, in a better condition. "Whence, then, ariſes (ſays the author) the phoſphoric light of the luciole? I am of opinion (adds he), that the light is peculiar and innate in theſe inſects, as ſeveral other productions are peculiar to other animals. As ſome animals have the faculty of accumulating the electric fluid, and of keeping it condenſed in particular organs, to diffuſe it afterwards at pleaſure, there may be other animals endowed with the faculty of keeping in a condenſed ſtate the fluid which conſtitutes light. It is poſſible, that by a peculiar organization they may have the power of extracting the light which enters into the compoſition of their food, and of tranſmitting it to the reſervoir deſtined for that purpoſe, which they have in their abdomen. It is not even impoſſible that they may have the power to extract from the atmoſpheric air the luminous fluid, as other animals have the power of extracting from the ſame air, by a chemical proceſs, the fluid of heat."

Carradori diſcovered, that the phoſphoreſcence of the luciole is a property independent of the life of theſe animals, and that it is chiefly owing to the ſoft ſtate of the phoſphoric ſubſtance. Its light is ſuſpended by drying, and it is again revived by ſoftening it in water; but only after a certain time of deſiccation. Reaumur, Beccaria, and Spallanzani, obſerved the ſame thing in regard to the *pholades* and the *meduſa*.

By plunging the luciole alternately into lukewarm and cold water, they ſhine with vivacity in the former, but their light becomes extinct in the latter; which, according to the author, depends on the alternate agreeable and diſagreeable ſenſation which they experience. In warm water their light diſappears gradually. Dr Carradori tried on the luciole and their phoſphorus the action of different ſaline and ſpirituous liquors, in which they exhibited the ſame appearances as other phoſphoric animals. Theſe laſt experiments prove that the phoſphoric matter of the luciole is only ſoluble in water.

LUDAMAR, a Mooriſh kingdom in the interior of Africa, of which the capital Beuorm is placed by Major Rennel in 15° N. Lat. and 6° 50′ W. Long. It has for its northern boundary the great deſert (ſee Sahara in this *Supplement*), and is deſcribed by Mr Park as little better than a deſert itſelf. Our traveller was taken captive on the confines of this kingdom, and carried to the camp of the king, where he was ſubjected

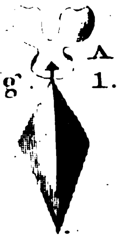


Fig. 1.

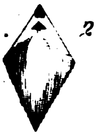


Fig. 2.

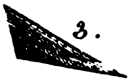


Fig. 3.

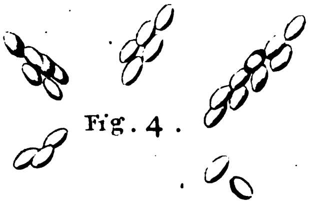
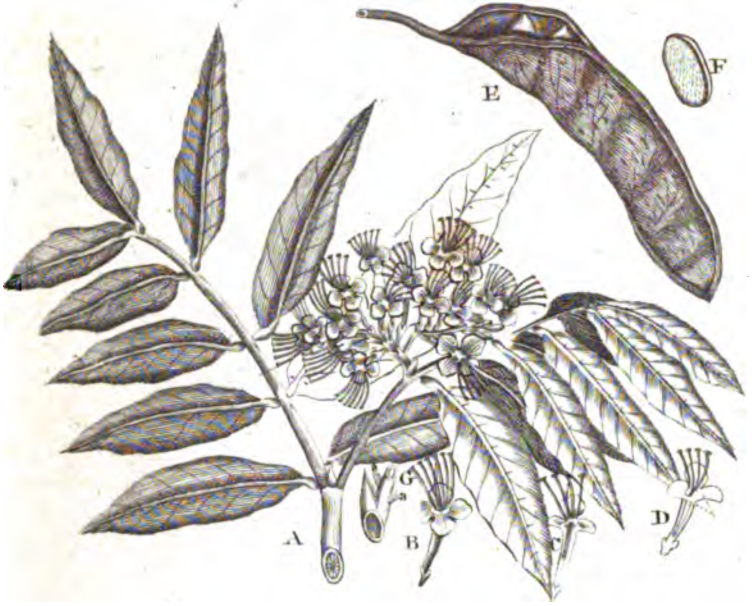


Fig. 4.

JONESIA.



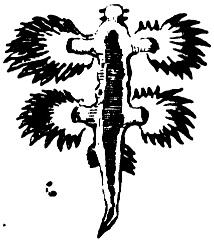


Fig. 5.

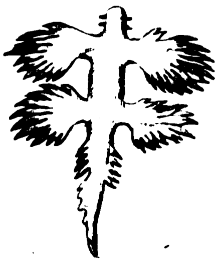
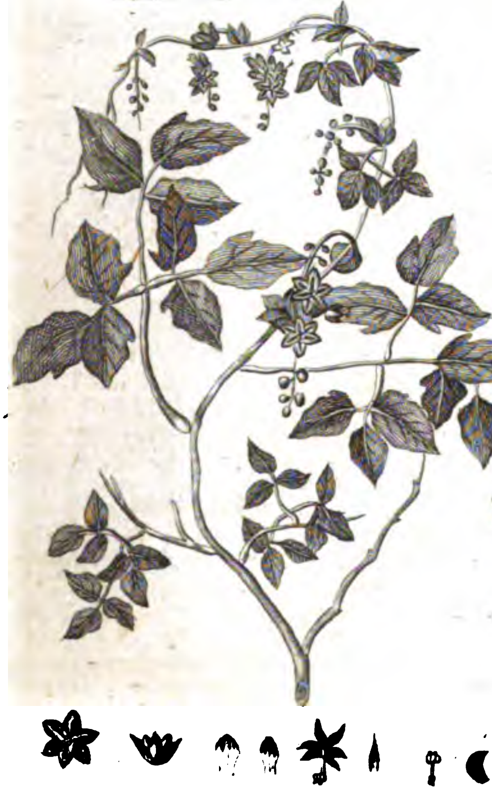
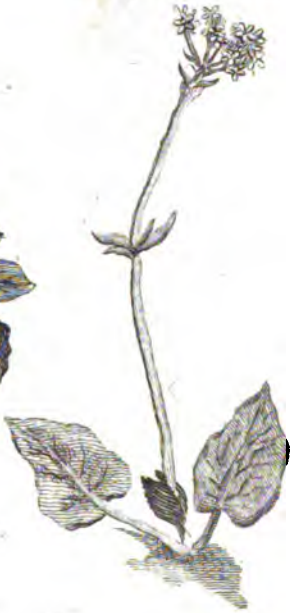


Fig. 6.

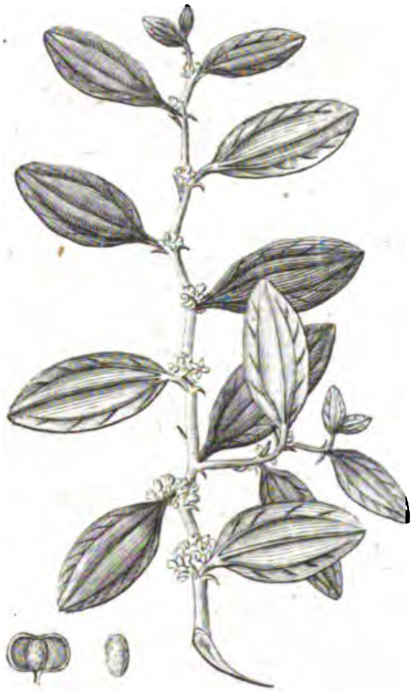
MALE LARDIZABALA.



INDIAN SPIKENARD.



LOTUS.



D. Lizars Sculp.

INVOLUTION. PLATE XXXI.

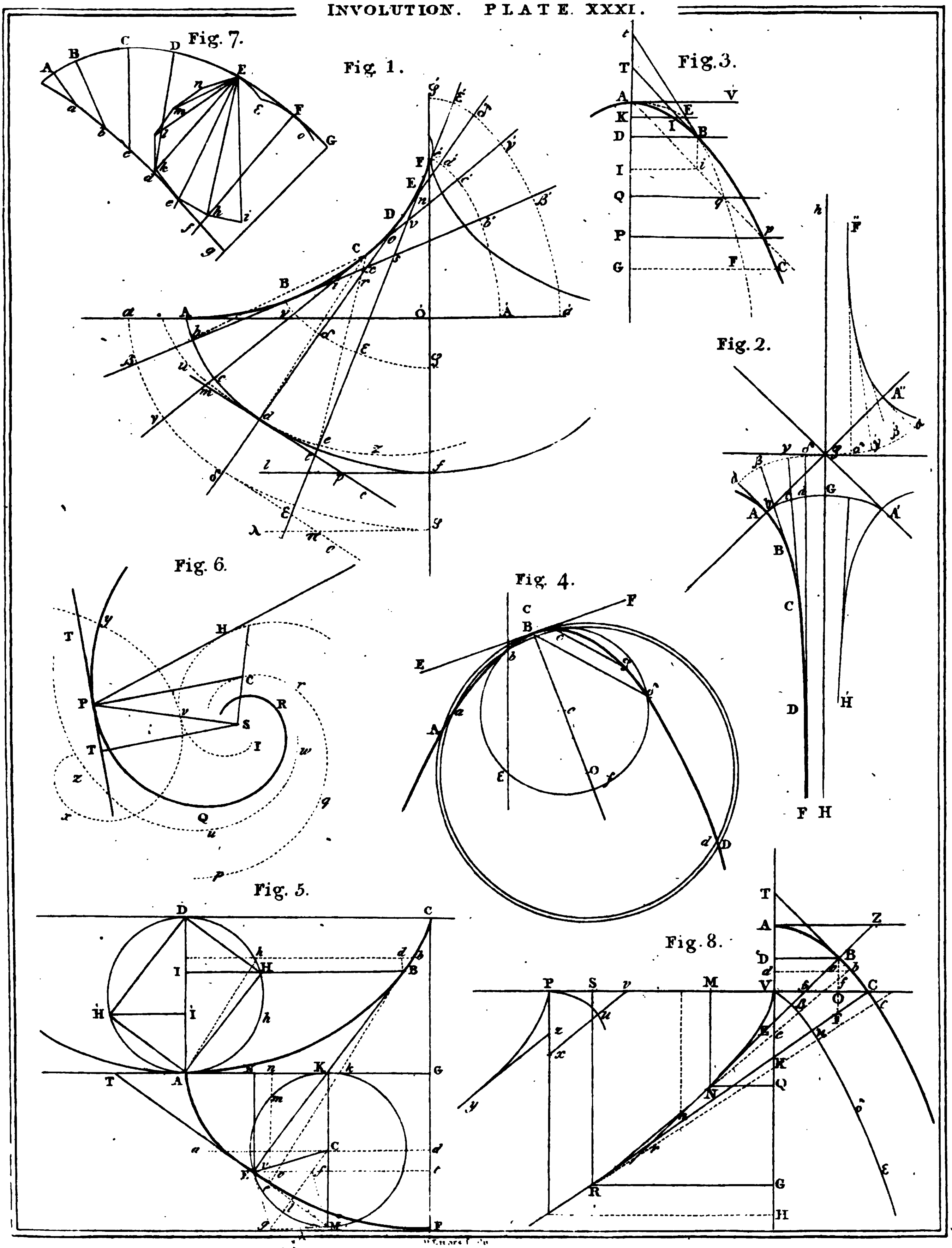


PLATE XXXII.

Fig 9.

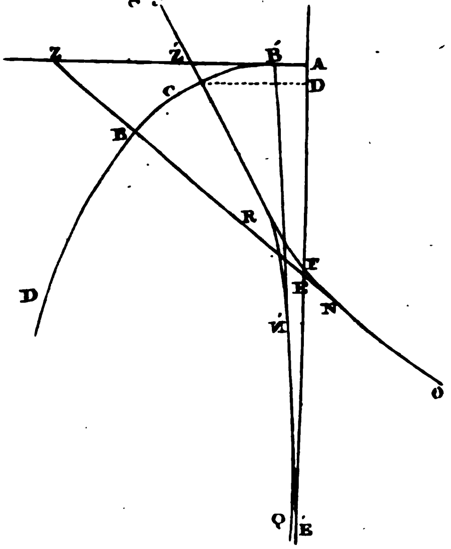


Fig 10.

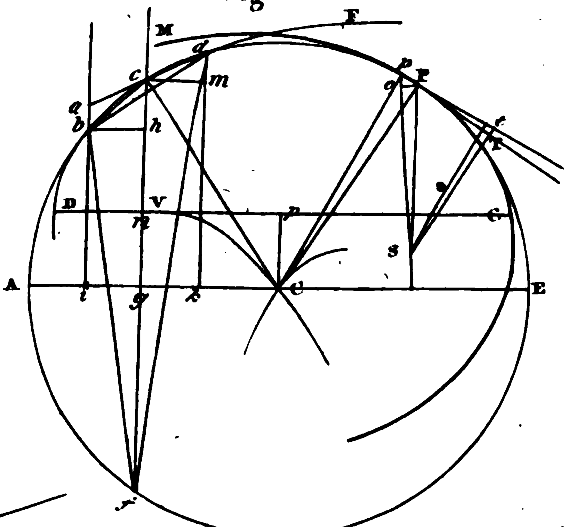


Fig 12.

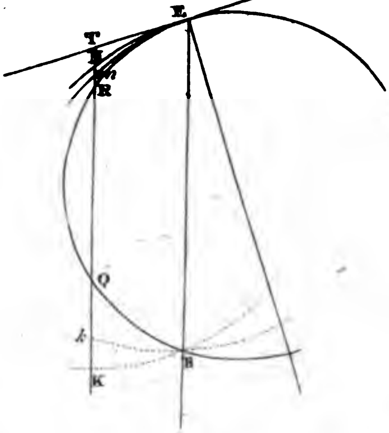


Fig 13.

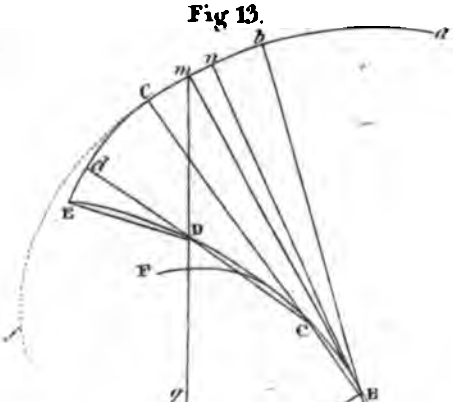
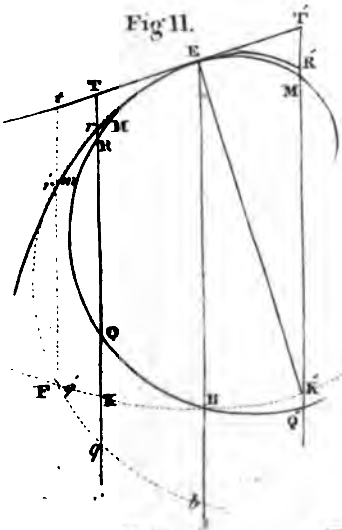
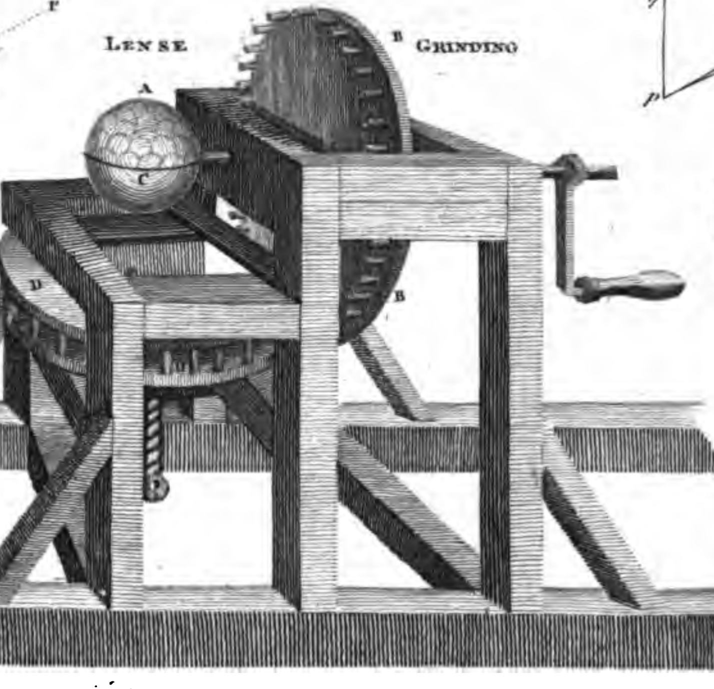


Fig 11.





ONISCUS.

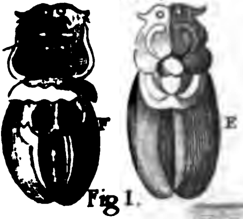


Fig 1.

ONISCUS.

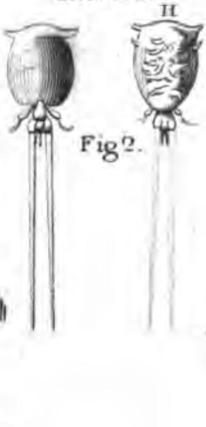


Fig 2.

D. Lizars Sculp.

to the crueleſt indignities that the malice of bigotted Moors could invent. He was not ſuffered to travel beyond the camp; though he moved as it moved, and of courſe ſaw a conſiderable part of the country, and had an opportunity of obſerving the manners of the people. "The Moors of Ludamar ſubſiſt chiefly on the fleſh of their cattle; and are always in the extreme of either gluttony or abſtinence. In conſequence of the frequent and ſevere faſts which their religion enjoins, and the toilſome journeys which they ſometimes undertake acroſs the deſert, they are enabled to bear both hunger and thirſt with ſurpriſing fortitude; but whenever opportunities occur of ſatiſfying their appetite, they generally devour more at one meal than would ſerve an European for three. They pay but little attention to agriculture; purchaſing their corn, cotton cloth, and other neceſſaries, from the Negroes, in exchange for ſalt, which they dig from the pits in the Great Deſert.

"The natural barrenneſs of the country is ſuch, that it furniſhes but few materials for manufacture. The Moors, however, contrive to weave a ſtrong cloth, with which they cover their tents; the thread is ſpun by their women from the hair of goats: and they prepare the hides of their cattle ſo as to furniſh ſaddles, bridles, pouches, and other articles of leather. They are likewiſe ſufficiently ſkilful to convert the native iron, which they procure from the Negroes, into ſpears and knives, and alſo into pots for boiling their food; but their ſabres and other weapons, as well as their fire-arms and ammunition, they purchaſe from the Europeans, in exchange for the Negro ſlaves which they obtain in their predatory excurſions. Their chief commerce of this kind is with the French traders on the Senegal river."

The Moors of this country have ſingular ideas of feminine perfection. The gracefulneſs of figure and motion, and a countenance enlivened by expreſſion, are by no means eſſential points in their ſtandard; with them corpulence and beauty appear to be terms nearly ſynonymous. A woman, of even moderate pretenſions, muſt be one who cannot walk without a ſlave under each arm to ſupport her; and a perfect beauty is a load for a camel. In conſequence of this prevalent taſte for unwieldineſs of bulk, the Mooriſh ladies take great pains to acquire it early in life; and for this purpoſe many of the young girls are compelled by their mothers to devour an immenſe quantity of food, and drink a large bowl of camel's milk every morning. It is of no importance whether the girl has an appetite or not, the meat and the drink muſt be ſwallowed; and obedience is frequently enforced by blows. This ſingular practice, inſtead of producing indigeſtion and diſeaſe, ſoon covers the young lady with that degree of plumpneſs, which, in the eye of a Moor, is perfection itſelf.

"Although the wealth of the Moors conſiſts chiefly in their numerous herds of cattle; yet, as the paſtoral life does not afford full employment, the majority of the people are perfectly idle, and ſpend the day in trifling converſation about their horſes, or in laying ſchemes of depredation on the Negro villages.

"The uſual place of rendezvous for the indolent is the king's tent, where great liberty of ſpeech ſeems to be exerciſed by the company towards each other. While in ſpeaking of their chief, they expreſs but one opinion. In praiſe of their ſovereign, they are unanimous. Songs are compoſed in his honour, which the company frequently ſing in concert; but they are ſo loaded with groſs adulation, that no man but a Mooriſh deſpot could hear them without bluſhing. The king is diſtinguiſhed by the fineneſs of his dreſs, which is compoſed of blue cotton cloth brought from Tombuctoo, or white linen or muſlin from Morocco. He has likewiſe a larger tent than any other perſon, with a white cloth over it; but in his uſual intercourſe with his ſubjects, all diſtinctions of rank are frequently forgotten. He ſometimes eats out of the ſame bowl with his camel driver, and repoſes himſelf, during the heat of the day, upon the ſame bed.

"The military ſtrength of Ludamar conſiſts in cavalry. They are well mounted, and appear to be very expert in ſkirmiſhing and attacking by ſurpriſe. Every ſoldier furniſhes his own horſe, and finds his accoutrements, conſiſting of a large ſabre, a double barrelled gun, a ſmall red leather bag for holding his balls, and a powder horn ſlung over the ſhoulder. He has no pay, nor any remuneration but what ariſes from plunder. This body is not very numerous; for when Ali the king made war upon Bambara, our author was informed that his whole force did not exceed 2000 cavalry. They conſtitute, however, by what he could learn, but a very ſmall proportion of his Mooriſh ſubjects. The horſes are very beautiful, and ſo highly eſteemed, that the Negro princes will ſometimes give from twelve to fourteen ſlaves for one horſe."

Cut off from all intercourſe with civilized nations, and boaſting an advantage over the Negroes, by poſſeſſing, though in a very limited degree, the knowledge of letters, the Moors of Ludamar are at once the vaineſt and proudeſt, and perhaps the moſt bigotted, ferocious, and intolerant of all the nations on the earth; combining in their character the blind ſuperſtition of the Negro with the ſavage cruelty and treachery of the Arab. It was with the utmoſt difficulty that our author made his eſcape from this inhoſpitable people.

LUPUS, the *Wolf*, a ſouthern conſtellation, joined to the Centaur, containing together 19 ſtars in Ptolomy's catalogue, but 24 in the Britannic catalogue.

LYNX, a conſtellation of the northern hemiſphere, compoſed by Hevelius out of the unformed ſtars. In his catalogue it conſiſts of 19 ſtars, but in the Britannic 44.

M.

MACHINERY.

THE denomination *Machine* is now vulgarly given to a great variety of ſubjects, which have very little analogy by which they can be claſſed with propriety under any one name. We ſay a travelling machine, a bathing machine, a copying machine, a threſhing machine, an electrical machine, &c. &c. The only circumſtance in which all theſe agree ſeem to be, that their conſtruction is more complex and artificial than the utenſils, tools, or inſtruments which offer themſelves to the firſt thoughts of uncultivated people. They are more artificial than the common cart, the bathing tub, or the flail. In the language of ancient Athens and Rome, the term was applied to every tool by which hard labour of any kind was performed; but in the language of modern Europe, it ſeems reſtricted either to ſuch tools or inſtruments as are employed for executing ſome philoſophical purpoſe, or of which the conſtruction employs the ſimple mechanical powers in a conſpicuous manner, in which their operation and energy engage the attention. An electrical machine, a centrifugal machine, are of the firſt claſs; a threſhing machine, a fire machine, are of the other claſs. It is nearly ſynonymous, in our language, with ENGINE; a term altogether modern, and in ſome meaſure honourable, being beſtowed only, or chiefly, on contrivances for executing work in which ingenuity and mechanical ſkill are manifeſt. Perhaps, indeed, the term *engine* is limited, by careful writers, to machines of conſiderable magnitude, or at leaſt of conſiderable art and contrivance. We ſay, with propriety, ſteam engine, fire-engine, plating-engine, boring-engine; and a dividing machine, a copying machine, &c. Either of theſe terms, *machine* or *engine*, are applied with impropriety to contrivances in which ſome piece of work is not executed on materials which are then ſaid to be manufactured. A travelling or bathing machine is ſurely a vulgariſm. A machine or engine is therefore a TOOL; but of complicated conſtruction, peculiarly fitted for expediting labour, or for performing it according to certain invariable principles: And we ſhould add, that the dependence of its efficacy on mechanical principles muſt be apparent, and even conſpicuous. The contrivance and erection of ſuch works conſtitute the profeſſion of the engineer; a profeſſion which ought by no means to be confounded with that of the mechanic, the artiſan, or manufacturer. It is one of the *artes liberales*; as deſerving of the title as medicine, ſurgery, architecture, painting, or ſculpture. Nay, whether we conſider the importance of it to this flouriſhing nation, or the ſcience that is neceſſary for giving eminence to the profeſſor, it is very doubtful whether it ſhould not take place of the three laſt named, and go *pari paſſu* with ſurgery and medicine. The inconſiderate reader, who peruſes *Cicero de Oratore* with ſatisfaction, is apt to ſmile at Vitruvius, who requires in his architect nearly the ſame accompliſhments which Cicero requires in his orator. He has not recollected, or perhaps did not know, that the profeſſion of an architect in the Auguſtan age was the moſt reſpectable of all thoſe which were not eſſentially connected with the management of ſtate affairs. It appears that the architects were all Greeks, or the pupils of Greeks, altogether different from the members of the *Collegium Murariorum*, the corporation of builders and maſons. The architecture of temples, ſtadiums, circuſes, amphitheatres, ſeems to have been monopoliſed, by ſtate authority, by a ſociety which had long ſubſiſted in Aſia, connected by certain myſterious bonds, both civil and religious. We find it in Syria; and we learn that it was brought thither from Perſia in very ancient times. From thence it ſpread into Ionia, where it became a very eminent and powerful aſſociation, under the particular protection of Bacchus, to whom the members had erected a magnificent temple at Teos, with a vaſt eſtabliſhment of prieſts and prieſteſſes, conſiſting of perſons of the firſt rank in the ſtate. They were the ſole builders of temples and ſtadiums throughout all Greece and the Leſſer Aſia; and the contractors for the machinery that was employed in the theatres, and in the great temples, for the celebration of the high myſteries of paganiſm. By the imperfect accounts which remain of the Eleuſinian and other myſteries, it appears, that this machinery muſt have been immenſe and wonderful, and muſt have required a great deal of mechanical ſkill. This indeed appears, in the moſt convincing manner, to any perſon who reflects on the magnificent ſtructures which they erected, which excite to this day the wonder of the world, not only on account of their magnificence and incomparable elegance, but alſo on account of the mechanical knowledge that ſeems indiſpenſably neceſſary for their erection. This will ever remain a myſtery. There are no traces of ſuch knowledge to be found in the writings of antiquity. Even Vitruvius, writing expreſsly on the ſubject, has given us nothing but what is in the loweſt degree of elementary knowledge.

This aſſociation of the Dyoniſiacs undoubtedly kept their mechanical ſcience a profound ſecret from the uninitiated, the profane. They were the engineers of antiquity, and Vitruvius was perhaps not one of the initiated. He ſpeaks of Myro and other Greek architects in terms of reſpect which border on veneration. Perhaps the modern aſſociation of free maſons is a remain of this antient fraternity, continued to our times by the company of builders, who erected the cathedrals and great conventual churches. No one who conſiders their works with ſcientific attention, can doubt of their being deeply verſed in the principles of mechanics, and even its more refined branches. They appear to have carried the art of vault-roofing almoſt to its acmé of perfection; far outſtripping their Grecian inſtructors in their knowledge of this moſt delicate branch of their art.

It were greatly to be wiſhed that ſome ſuch inſtitution did yet exiſt, where men might be induced by the moſt powerful motives to accompliſh themſelves in the knowledge neceſſary for attaining eminence in their profeſſion.

We have been informed (and we thought our authority good), that our gracious Sovereign has ſignified his intention of patroniſing an inſtitution of this kind. We heard, that it was propoſed to inſtitute degrees ſimilar to our univerſity degrees, and proceeding on ſimilar conditions of a regular education or ſtanding, which would enſure the *opportunities* of information, and alſo on an examination of the proficiency of the candidate. This examination, being conducted by perſons eminent in the profeſſion, perhaps ſtill exerciſing it, would probably be ſerious, becauſe the ſucceſsful candidate would immediately become a rival practitioner. Such an inſtitution would undoubtedly prevent many groſs impoſitions by unlettered mill-wrights and pump-makers, who now ſeldom appear under any name but that of engineer, although they are frequently ignorant even of the elements of mechanical ſcience, and are totally unacquainted with the higher mathematics; without which, it is abſolutely impoſſible for them to contrive a machine well ſuited to the intended purpoſe, or to ſay with any tolerable preciſion what will be the performance of the engine they have erected. Yet theſe are queſtions ſuſceptible of accurate ſolution, becauſe they depend on the unalterable laws of matter and motion.

All who have a juſt view of the unſpeakable advantages which this highly favoured land poſſeſſes in the ſuperiority and activity of its manufactures, and who know how much of this ſuperiority ſhould be aſcribed to the great improvements which have been made in practical mechanics within theſe laſt thirty years, will join us in wiſhing ſucceſs to ſome ſuch inſtitution as that now mentioned.

We were naturally led to theſe reflections when we turned our thoughts to machinery in general, and obſerved what is done in this country by the native energy of its inhabitants, unaſſiſted by ſuch ſcientific inſtructions as they might have expected from the pupils of a Newton, their countryman, under the patronage of the beſt of Sovereigns, eminently knowing in theſe things, and ever ready to encourage thoſe ſciences and arts which have ſo highly contributed to the national proſperity. What might not be reaſonably expected from Britiſh activity, if thoſe among ourſelves who have knowledge and leiſure had been at the ſame pains with the members of the foreign academies to cultivate the Newtonian philoſophy, and particularly the more refined branches of mechanics, and to deduce from their ſpeculations maxims of conſtruction fitted to our ſituation as a great manufacturing nation? But ſuch knowledge is not attainable by thoſe who are acquainted only with the imperfect elements contained in the publications read by the bulk of our practitioners. Much to this purpoſe has been done on the continent by the moſt eminent mathematicians; but from want of individual energy, or perhaps of general ſecurity and protection, the patriotic labours of thoſe gentlemen have not done the ſervice to their country which might have been reaſonably expected. Indeed, their diſſertations have generally been ſo compoſed, that only the learned could ſee their value. They ſeem addreſſed only, or chiefly, to ſuch; but it is to thoſe authors that our countrymen generally have recourſe for information concerning every thing in their profeſſion that riſes above mere elementary knowledge. The books in our language which profeſs to be ſyſtems of mechanics rarely go beyond this: they contain only the principles of equilibrium. Theſe are abſolutely neceſſary for the knowledge of machines; but they are very far indeed from giving what may be called a practical knowledge of *working machinery*. This is never in a ſtate of equilibrium. The machine muſt move in order to work. There muſt be a ſuperiority of impelling power, beyond what is merely ſufficient for balancing the reſiſtance or contrary action of the work to be performed. The reader may turn to the article STATICS in the *Encyclopædia Britannica*, and he will there ſee ſome farther obſervations on this head. And in the article MECHANICS he will find a pretty ample detail of all the uſual doctrines, and a deſcription of a conſiderable variety of machines or engines, accompanied by ſuch obſervations as are neceſſary for tracing the propagation or tranſmiſſion of preſſure from that part of the machine to which the natural power is applied to the working part of the machine. Along with theſe two articles, it will be proper to read with peculiar attention the article ROTATION.

By far the greateſt number of our moſt ſerviceable engines conſiſt chiefly of parts which have a motion of rotation round fixed axes, and derive all their energy from levers virtually contained in them. And theſe acting parts are alſo material, requiring force to move them over and above what is neceſſary for producing the acting force at the working part of the machine. The modifications which this circumſtance frequently makes of the whole motions of the machine, are indicated in the article ROTATION in an elementary way; and the propoſitions there inveſtigated will be found almoſt continually involved in the complete theory of the operation of a machine. Laſtly, it will be proper to conſider attentively the propoſitions contained in the article *STRENGTH of Materials*, that we may combine them with thoſe which relate wholly to the working of the machine; becauſe it is from this combination only that we diſcover the ſtrains which are excited at the various points of ſupport, and of communication, and in every member of the machine. We ſuppoſe all theſe things already underſtood.

1
The chief queſtion in mechanics.

Our object at preſent is to point out the principles which enable us to aſcertain what will be the preciſe motion of a machine of given conſtruction, when actuated by a natural power of known intenſity, applied to a given point of the machine, while it is employed to overcome a known reſiſtance acting at another point. To abbreviate language, we ſhall call that the IMPELLED POINT of the machine to which the preſſure of the moving power is immediately applied; and we may call that the WORKING POINT, where the reſiſtance ariſing from the work to be performed immediately acts.

To conſider this important ſubject, even in its chief varieties, requires much more room than can be allowed in an undertaking like ours, and therefore we muſt content ourſelves with a very limited view; but at the ſame time, ſuch a view as ſhall give ſufficient indication of the principles which ſhould direct the practical reader in every important caſe. We ſhall conſider thoſe machines which perform their motions round fixed axes; theſe being by far the moſt numerous and important, becauſe they involve in their conſtruction and operations all the leading principles.

2 The proper meaſure of mechanical power exerted.

That we may proceed ſecurely, it is neceſſary to have a preciſe and adequate notion of moving force, as applied to machinery, and of its meaſures. We think this peculiarly neceſſary. Different notions have been entertained on this ſubject by Mr Leibnitz, Des Cartes, and other eminent mechanicians of the laſt century; and their ſucceſſors have not yet come to an agreement. Nay, ſome of the moſt eminent practitioners of the preſent times (for we muſt include Mr Smeaton in the number) have given meaſures of mechanical power in machinery which we think inaccurate, and tending to erroneous concluſions and maxims.

We take for the meaſure (as it is the effect) of exerted mechanical power the quantity of motion which it produces by its uniform exertion during ſome given time. We ſay *uniform exertion*, not becauſe this uniformity is neceſſary, but only becauſe, if any variation of the exertion has taken place, it muſt be known, in order to judge of the power. This would needleſsly complicate the calculations; but in whatever way the exertion may have varied, the whole accumulated exertion is ſtill accurately meaſured by the quantity of motion exiſting at the end of the exertion. The reader muſt perceive that this is the ſame thing that is expreſſed in the article DYNAMICS of this *Supplement*, n° 90. by the area of the figure whoſe abſciſſa or axis repreſents the time of exertion; and the ordinates are as the preſſures in the different inſtants of that time, the whole being multiplied by the number of particles (that is, by the quantity of matter), becauſe that figure repreſents the quantity of motion generated in one particle of matter only. All this is abundantly clear to perſons converſant in theſe diſquiſitions; but we wiſh to carry along with us the diſtinct conceptions of that uſeful claſs of readers whoſe profeſſion engages them in the conſtruction and employment of machines, and to whom ſuch diſcuſſions are not ſo familiar. We muſt endeavour therefore to juſtify our choice of this meaſure by appealing to familiar facts.

If a man, by preſſing uniformly on a maſs of matter for five ſeconds, generates in it the velocity of eight feet per ſecond, we obtain an exact notion of the proportion of this exertion to the mechanical exertion of gravity, when we ſay that the man's exerted force has been preciſely one-twentieth part of the action of gravity on it; for we know that the weight of that body (or, more properly, its heavineſs) would, in five ſeconds, have given it the velocity of 160 feet per ſecond, by acting on it during its fall. But let us attend more cloſely to what we mean by ſaying that the exerted force is one-twentieth of the exertion of gravity. The only notion we have of the exertion of gravity is what we call the weight of the body—the preſſure which we feel it make on our hand. To ſay that this is 20 pounds weight, does not explain it; becauſe this is only the action of gravity on another piece of matter. Both preſſures are the ſame. But if the body weighs 20 pounds, it will draw out the rod of a ſteelyard to the mark 20. The rod is ſo divided, that the 20th part of this preſſure will draw it out to 1. Now the fact is, that if the man preſſes on the maſs of 20 pounds weight with a ſpring ſteelyard during five ſeconds, and if during that time the rod of the ſteelyard was always at the mark 1, the body will have acquired the velocity of eight feet per ſecond. This is an acknowledged fact. Therefore we were right in ſaying, that the man's exertion is one-twentieth of the exertion of gravity. And ſince we believe the weight of bodies to be proportional to their quantity of matter, all matter being equally heavy, we may ſay, that the man's exertion was equal to the action of gravity on a quantity of matter whoſe weight is one pound. We expreſs it much more familiarly, by ſaying, that the man exerted on it the preſſure of one pound of matter, or the force of one pound.

In this manner, the motion communicated to a maſs of matter, by acting on it during ſome time, informs us with accuracy of the real mechanical force or preſſure which has been exerted. This is judged to be double when twice the velocity has been generated in the ſame maſs, or where the ſame velocity has been generated in twice the maſs; becauſe we know, that a double preſſure would have done either the one or the other.

But farther: We know that this preſſure is the exertion; we have no other notion of our own force; and our notion of gravity, of elaſticity, or any other natural force, is the ſame. We alſo know that the continuance of this exertion fatigues and exhauſts our ſtrength as completely as the moſt violent motion. A dead pull, as it is called, of a horſe, at a poſt fixed in the ground, is a uſual trial of his ſtrength. No man can hold out his arm horizontally for much more than a quarter of an hour; and the exertion of the laſt minutes gives the moſt diſtreſſing fatigue, and diſables the ſhoulder from action for a conſiderable time after. This is therefore an expenditure of mechanical power, in the ſtrict primitive ſenſe of the word. Of this expenditure we have an exact and adequate effect and meaſure in the quantity of motion produced; that is, in the product of the quantity of matter by the velocity generated in it by this exertion. And it muſt be particularly noticed, that this meaſure is applicable even to caſes where no motion is produced by the exertion; that is, if we know that the exertion which is juſt unable to ſtart a block of ſtone lying on a ſmooth ſtone pavement, but would ſtart it, if increaſed by the ſmalleſt addition; and if we know that this would generate in a ſecond 32 feet of velocity in 100 pounds of matter—we are certain that it was a preſſure equal to the weight of this 100 pounds. It is a good meaſure, though not immediate, and may be uſed without danger of miſtake when we have no other.

3 Mr Smeaton's meaſure

The celebrated engineer Mr Smeaton, in his excellent diſſertation on the power of water and wind to drive machinery, and alſo in two other diſſertations, all publiſhed in the Philoſophical Tranſactions, and afterwards in a little volume, has employed another meaſure, both of the expenditure of mechanical power, and of the mechanical effect produced. He ſays, that the weight of a body, multiplied by the height thro' which it deſcends, while driving a machine, is the only proper meaſure of the power expended; and that the weight, multiplied by the height through which it is uniformly raiſed, is the only proper meaſure of the effect produced. And he produces a large train of accurate experiments to prove that a certain weight, deſcending through a certain ſpace, always produces the ſame effect, whether it has deſcended ſwiftly or ſlowly, employing little or much time.

Had this eminent engineer propoſed this as a popular meaſure, of eaſy comprehenſion and remembrance, and as well accommodated to the uſes of thoſe engaged in the conſtruction of machines, when reſtricted to a certain claſs of caſes, it might have anſwered very good purpoſes; but the author is at pains to recommend it to the philoſophers as a neceſſary correction of their theories, which he ſays tend to miſlead the artiſts. His own reaſonings terminate in the ſame concluſion with Mr Leibnitz's, namely, that the power of producing a mechanical effect, and the effect produced, are proportional to the ſquare of the velocity. The deference juſtly due to Mr Smeaton's authority, and the influence of his name among thoſe who are likely to make the moſt uſe of his inſtructions, render it neceſſary for us to examine this matter with ſome attention.

Mr Smeaton was led to the adoption of this meaſure by his profeſſional habits. Raiſing a weight to a height is, in one ſhape or another, the general taſk of the machines he was employed to erect; and we may add, the opportunities of expending the mechanical powers of nature which are in our command, are generally in this proportion. A certain daily ſupply of water, coming from a certain height, is our beſt opportunity, and may very properly be ſaid to be expended.

4 Examined, This being the general caſe, the meaſure was obvious, and natural, and good. The power and effect were of the ſame kind, and *muſt* be meaſures of each other; at leaſt, in thoſe circumſtances in which they were ſet in oppoſition. Yet even here Mr Smeaton was obliged to make a reſtriction of his meaſures: "The height thro' which a body *ſlowly and equably* deſcended, or to which it was raiſed." And why was this limitation neceſſary? "Becauſe in rapid or accelerated motions, the inertia of bodies occaſioned ſome variation *." But this is too vague language for philoſophical diſquiſition. Beſides, what is meant by this variation? What is the ſtandard from which the unreſtricted meaſure varies? This ſtandard, whatever it is, is the true meaſure, and it was needleſs to adopt any other. Now, the ſtandard from which Mr Smeaton eſtimates the deviation, is the very meaſure which we wiſh to employ, namely, the quantity of motion produced. Strictly ſpeaking, even this is not the immediate meaſure. The immediate meaſure is that faculty which we call preſſure. This is the intermedium perceivable in all productions of motion; and it is alſo the intermedium of mechanical effect, even when motion is not produced; as when the weight of a body bends a ſpring, or the elaſticity of a body ſupports another preſſure. How it operates in all or any of theſe caſes, we know not; but we know that all theſe meaſures of preſſure agree with each other. A double quantity of motion will bend a ſpring doubly ſtrong, will raiſe a double weight, will withſtand any double preſſure, &c. &c. In ſhort, preſſure is the immediate agent in every mechanical phenomenon. It penetrates bodies, overcoming their tenacity; it overcomes friction; it balances preſſure; it produces motion. Mr Smeaton's meaſure is only nearly true, in any caſe, and in all caſes it is far from being exact in the firſt inſtants of the motion, during its acceleration or retardation.

We have already noticed the complete expenditure of animal power by continued preſſure, even when motion is not produced: the only difficulty is to connect this in a meaſurable way with the power which the ſame exertion has of generating motion in a body.

When a man ſupports a weight for a ſingle inſtant, he certainly balances the preſſure or action of gravity on that body; and he continues this action as long as he continues to ſupport it: and we know that if this body were at the end of a horizontal arm turning round a vertical axis, the ſame effort which the man exerted in merely carrying the weight, if now exerted on the body, by puſhing it horizontally round the axis, will generate in it the ſame velocity which gravity would generate by its falling freely. On this authority therefore we ſay, that the whole accumulated action of a man, when he has juſt carried a body whoſe weight is 30 pounds for one minute, is equal to the whole exertion of gravity on it during that minute; and if employed, not to counteract gravity, but to generate motion, would generate, during that minute, the ſame motion that gravity would, that is, 60×32 feet velocity per ſecond, in a maſs of 30 pounds. There would be 30 pounds of matter moving with the velocity of 1920 feet per ſecond. We would expreſs this production or effect by 30×1920, or by 57600, as the meaſure of the man's exertion during the minute.

But, according to Mr Smeaton, there is no expenditure of power, nor any production of mechanical effect, in thus carrying 30 pounds for a minute; there is no product of a weight by a height through which it is equably raiſed; yet ſuch exertion will completely exhauſt a man's ſtrength if the body be heavy enough. Here then is a caſe to which Mr Smeaton's meaſure does not readily apply; and this caſe is important, including all the actions of animals at a dead pull.

But let us conſider more narrowly what a man really does when he performs what Mr Smeaton allows to be the production of a meaſurable mechanical effect. Suppoſe this weight of 30 pounds hanging by a cord which paſſes over a pulley, and that a man, taking this cord over his ſhoulder, turns his back to the pulley, and walks away from it. We know, that a man of ordinary force will walk along, raiſing this weight, at the rate of about 60 yards in a minute, or a yard every ſecond, and that he can continue to do this for eight or ten hours from day to day; and that this is all that he can do without fatigue. Here are 30 pounds raiſed uniformly 180 feet in a minute; and Mr Smeaton would expreſs this by 30×180, or 5400, and would call this the meaſure of the mechanical effect, and alſo of the expenditure of power. This is very different from our meaſure 57600.

5 And found to be inaccurate. But this is not an accurate and complete account of the man's *action* on the weight, and of the whole effect produced. To be convinced of this, ſuppoſe that a man A has been thus employed, while another B, walking along ſide of him at the ſame rate, ſuddenly takes the rope out of his hand, frees him of the taſk, and *continues* to raiſe the weight without the ſmalleſt change on its velocity of aſcent. What is the action of B, and whether is it the ſame with that of A or not? It is acknowledged by all, that the exertion of B againſt the load is preciſely equal to 30 pounds. If he holds the rope by a ſpring ſteelyard, it will ſtand conſtantly at the mark 30. B exerts the ſame action on the load as

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when he ſimply ſupports it from falling back into the pit. It was moving with the velocity of three feet per ſecond when he took hold of the rope, and it would continue to move with that velocity if any thing could annihilate or counteract its gravity. If therefore there was no action when a perſon merely carried it, there is none at preſent when it is riſing 180 feet in a minute. The man does indeed work more than on that occaſion, but not againſt the load: his additional work is walking, the motion of his own body, as a thing previouſly neceſſary that he may continue to ſupport the load, that he may continue his mechanical effort as it follows him. It appears to yield to him: but it is not to *his* efforts that it yields; its weight completely balances thoſe efforts, and is balanced by them. It was to a *greater* effort of the man A that it yielded. It was then lying on the ground. He pulled at the cord, gradually perhaps increaſing his pull till it was juſt equal to its weight. When this obtains, the load no longer preſſes on the ground, but is completely carried by the rope. But it does not move by this effort of 30 pounds; but let him exert a force of 31 pounds, and continue this for three ſeconds. He will put it in motion; will accelerate that motion; and at the end of three ſeconds the load is riſing with the velocity of three feet per ſecond. The man feels that this is as much ſpeed as he can continue in his walk; he therefore ſlackens his pull, reducing his action to 30 pounds, and with this action he walks on. All this would be diſtinctly perceived by means of a ſteelyard. The rod would be pulled out beyond 30, till the load acquired the uniform velocity intended, and after this it would be obſerved to ſhrink back to 30.

More is done therefore than appears by Mr Smeaton's meaſure. Indeed, all that appears in it is the exertion neceſſary for *continuing* a motion already produced, but which would be immediately extinguiſhed by a contrary power, which muſt therefore be counteracted. This meaſure will not apply to numberleſs caſes of the employment of machines, where there is no ſuch oppoſing power, and where, notwithſtanding, mechanical power muſt be expended, even according to Mr Smeaton's meaſurement. Such are corn mills, boring mills, and many others.

How then comes it that Mr Smeaton's valuable experiments concur ſo exactly in ſhewing that the ſame quantity of water deſcending from the ſame height, always produces the ſame effect (as he meaſured it), whatever be the velocity? In the firſt place, all his experiments are caſes where the power expended and the work performed are of the ſame kind: A heavy body deſcends, and by its preponderancy raiſes another heavy body. But even this would not enſure the preciſe agreement obſerved in his experiments, if Mr Smeaton were not careful to exclude from his calculations all that motion where there is any acceleration, and all the expenditure of water during the acceleration, and to admit only thoſe motions that are ſenſibly uniform. In moderate velocities, the additional preſſure required for the firſt acceleration is but an inſignificant part of the whole; and to take theſe accelerated motions into the account, would have embarraſſed the calculations, and perhaps confuſed many of the readers. We ſee, in the inſtance now given, that the addition of one pound continued for three ſeconds only, was all that was neceſſary.

Mr Smeaton's meaſurement is therefore abundantly exact for practice; and being accommodated to the circumſtances moſt likely to engage the attention, is very proper for the inſtruction of the numerous practitioners in all manufacturing countries who are employed for ordinary erections: but it is improperly propoſed as an article eſſential to a juſt theory of mechanics, and therefore it was proper to notice it in this place. Beſides, there frequently occur moſt important caſes, in which the motion of a machine is, of neceſſity, deſultory, alternately accelerated, and retarded. We ſhould not derive all the advantages in our power from the firſt mover, if we did not attend particularly, and chiefly, to the *accelerating* forces. And in every caſe, the improvement, or the proper employment of the machine, is not attained, if we are not able to diſcriminate between the two parts of the mechanical exertion; one of them, by which the motion is produced and accelerated to a certain degree; and the other, by which that motion is continued. We muſt be able to appreciate what part of the effect belongs to each.—But it is now time to proceed to the important queſtion,

What will be the preciſe motion of a machine of given conſtruction, actuated by a power of known intenſity and manner of acting, and oppoſed by a known reſiſtance?

6 Things to be conſidered in a machine at work.

In the ſolution of this queſtion, much depends on the nature of both power and reſiſtance. In the ſtatical conſideration of machines, no attention is paid to any differences. The intenſity of the preſſures is all that it is neceſſary to regard, in order to ſtate the proportion of preſſure which will be exerted in the various parts of the machine. The preſſures at the impelled and working points, combined with the proportions of the machine, neceſſarily determine all the reſt. Preſſure being the ſole cauſe of all mechanical action among bodies, any preſſure may be ſubſtituted for another that is equal to it; and the preſſure which is moſt familiar, or of eaſieſt conſideration, may be uſed as the repreſentative of all others. This has occaſioned the mechanical writers to make uſe of the preſſure of gravity as the ſtandard of compariſon, and to repreſent all powers and reſiſtances by weights. However proper this may be in their hands, it has hurt the progreſs of the ſcience. It has rendered the uſual elementary treatiſes of mechanics very imperfect, by limiting the experiments and illuſtrations to ſuch as can be ſo repreſented with facility. This has limited them to the ſtate of equilibrium (in which condition a working machine is never found), becauſe illuſtrations by experiment out of this ſtate are neither obvious nor eaſy. It has alſo prevented the ſtudents of mechanics from accompliſhing themſelves with the mathematical knowledge required for a ſucceſsful proſecution of the ſtudy. The moſt elementary geometry is ſufficient for a thorough underſtanding of equilibrium, or the doctrines of ſtatics; but true mechanics, the knowledge of machines as inſtruments by which work is performed, requires more refined mathematics, and is inacceſſible without it.

Had not Newton or others improved mathematics by the invention of the infiniteſimal analyſis and calculus, we muſt have reſted contented with the diſcoveries (really great) of Galileo and Huyghens. But Newton,

ton, *ſuâ matheſi facem præferente*, opened a boundleſs field of inveſtigation, and has not only given a magnificent and brilliant ſpecimen of the diſcoveries to be made in it, but has alſo traced out the particular paths in which we are to find the ſolution of all queſtions of practical mechanics. This he has done by ſhewing another ſpecies of equilibrium, indicated, not by the ceſſation of all motion, but by the uniformity of motion; by the ceſſation of all acceleration or retardation. As the extinction of motion by the action of oppoſite forces is aſſumed by us as the indication of the perfect equality of thoſe forces; ſo the extinction of acceleration ſhould be received as the indication of ſomething equal and oppoſite to the force which was known to have cauſed the acceleration; and therefore as the indication of an equilibrium between oppoſite forces, or elſe of the ceſſation of all force.

7
Mechanical equilibrium

This new view of things was the ſource of all our diſtinct notions of mechanical forces, and gave us our only unexceptionable marks and meaſures of them. The 39th propoſition of the firſt book of Newton's Principles of Natural Philoſophy, and its corollaries, contain almoſt the whole doctrine of active mechanical nature, and are peculiarly applicable to our preſent purpoſe, becauſe they enable us to comprehend in this *mechanical equilibrium* (ſo different from the *ſtatical*) every circumſtance in which thoſe preſſures which are exerted by natural powers differ from each other, and vary in their action on the impelled and working points of a machine. Indeed, when we recollect that the operations of our machines are the ſame on board a ſhip as on ſhore, and that all our machines are moving with the ground on which they ſtand, we muſt acknowledge, that even ordinary ſtatics is only an imperfect view of an equilibrium among things which are in motion; and this ſhould have taught us that, even in thoſe caſes where nothing like equilibrium appears, an equilibrium may ſtill be uſefully traced.

8
Diſtinctions muſt be made in the nature of the powers applied to working machines.

In the ſtatical conſideration of machines, the *quantity* of preſſure is all that we need attend to. But in the mechanical diſcuſſion of their *operations*, we muſt attend to their diſtinctions in kind: and it will by no means be ſufficient to repreſent them all by weights; for their diſtinction in kind is accompanied by great differences in their manner of acting on the machine. Some natural powers, in order to continue their action on the impelled point of the machine, muſt at the ſame time put into motion a quantity of matter external to the machine, in which theſe powers reſide; and this muſt be made to follow the impelled point in its motion, and not only follow, but continue to preſs it forward; or, this matter, thus continually put into motion, muſt be ſucceſſively applied to different points of the machine, which become impelled points in their turn. This is the caſe with a weight, with the action of a ſpring, the action of animals, the action of a ſtream of water or wind, and many other powers. A part of the natural mechanical powers muſt therefore be employed in producing this external motion. This is ſometimes a very conſiderable part of the whole natural power. In ſome caſes it is the whole of it. This obtains in the action of a deſcending weight, lying on the end of a lever and preſſing it down, or hanging by a chord attached to the machine.

There is alſo an important diſtinction in the manner in which this external motion is kept up. In a weight employed as the moving power, the actuating preſſure ſeems to reſide in the matter itſelf; and all that is neceſſary for continuing this preſſure is merely to continue the connection of it with the machine. But in the action of animals it may be very different: A man puſhing at a capſtan bar, muſt firſt of all walk as faſt as the bar moves round, and this requires the expenditure of his muſcular force. But this alone will not render his action an effective power: He muſt alſo *preſs forward* the capſtan bar with as much force as he has remaining over and above what he expends in walking at that rate. The proportion of theſe two expenditures may be very different in different circumſtances; and in the judicious ſelection of ſuch circumſtances as make the firſt of theſe as inconſiderable as poſſible, lies much of the ſkill and ſagacity of the engineer. In the common operation of thraſhing corn, much more than half of the man's power is expended in giving the neceſſary motion to his own body, and only the remainder is employed in urging forward the ſwiple with a momentum ſufficient for ſhaking off the ripe grains from the ſtalk. We had ſufficient proof of this, by taking off the ſwiple of the flail, and putting the ſame weight of lead on the end of the ſtaff, and then cauſing the hind to perform the uſual motions of thraſhing with all the rapidity that he could continue during the ordinary hours of work. We never could find a man who could make three motions in the ſame time that he could make two in the uſual manner, ſo as to continue this for half an hour. Hence we muſt conclude, that half (ſome will ſay two-thirds) of a thraſher's power is expended in merely moving his own body. Such modes of animal action will therefore be avoided by a judicious engineer; but to be avoided, their inconvenience muſt be underſtood. More of this will occur hereafter.—In other caſes, we are almoſt (never wholly) free from this unprofitable expenditure of power. Thus, in the ſteam engine, the operation requires that the external air follow the piſton down the cylinder, in order to continue its preſſure. But the force neceſſary for ſending in this rare fluid into the cylinder with the neceſſary velocity, is ſuch an inſignificant part of the whole force which is at our command, that it would be ridiculous affectation in any engineer to take it into account; and this is one great ground of preference to this natural power. The ſame thing may be ſaid of the action of a ſtrong and light ſpring, which is therefore another very eligible firſt mover for machinery. The ancient artilleriſts had diſcovered this, and employed it in their warlike engines.

We muſt alſo attend to the nature of the reſiſtance which the work to be performed oppoſes to the motion of our machine. Sometimes the work oppoſes, not a ſimple obſtruction, but a real reſiſtance or reaction, which, if applied alone to the machine, would cauſe it to move the contrary way. This always obtains in caſes where a heavy body is to be raiſed, where a ſpring is to be compreſſed, and in ſome other caſes. Very often, however, there is no ſuch contrary action. A flour mill, a ſaw mill, a boring mill, and many ſuch engines, exhibit no reaction of this kind. But although ſuch machines, when at reſt or not impelled by the firſt mover, ſuſtain no preſſure in the oppoſite direction, yet they will not acquire any motion whatever, unleſs they be impelled by a power of a certain determinate intenſity. Thus in a ſaw mill, a certain force muſt be impreſſed on the teeth of the ſaw, that the coheſion of the fibres of the timber may be overcome. This requires that a certain force, determined by the proportions of the machine, be impreſſed on the impelled point. If this, and no more, be applied there, a force will be excited at the teeth of the ſaw, which will *balance* the coheſion of the wood, but will not *overcome* it. The machine will continue at reſt, and no work will be performed. Any addition of force at the impelled point, will occaſion an addition to the force excited in the teeth of the ſaw. The coheſion will be overcome, the machine will move, and work will be performed. It is only this *addition* to the impelling power that gives motion to the machine; the reſt being expended merely in balancing the coheſion of the woody fibres. While therefore the machine is in motion, performing work, we muſt conſider it as actuated by a force impreſſed on the impelled point by the natural power, and by another acting at the working point, furniſhed by or derived from the reſiſtance of the work.

Again: It not unfrequently happens, that there is not even any ſuch reſiſtance or obſtruction excited at the working point of the machine; the whole reſiſtance (if we can with propriety give it that name) ariſes from the neceſſity of giving motion to a quantity of inert and inactive matter. This happens in urging round a heavy fly, as in the coining preſs, in the punching engine, in drawing a body along a horizontal plane without friction, and a few ſimilar caſes. Here the ſmalleſt force whatever, applied at the impelled point, will begin motion in the machine; and the *whole* force ſo applied is conſumed in this ſervice. Such caſes are rare, as the ultimate performance of a machine; but occaſionally, and for a farther purpoſe, they frequently occur; and it is neceſſary to conſider them, becauſe there are many of the moſt important applications of machinery where a very conſiderable part of the force is expended in this part of the general taſk.

Such are the chief circumſtances of diſtinction among the mechanical powers of nature which muſt be attended to, in order to know the motion and performance of a machine. Theſe never occur in the ſtatical conſideration of the machine, but here they are of chief importance.

9 The inertia of the machine itſelf muſt alſo be conſidered,

But farther: The action of the moving power is transferred to the working point through the parts of a machine, which are material, inert, and heavy. Or, to deſcribe it more accurately, before the neceſſary force can be excited at the working point of the machine, the various connecting forces muſt be exerted in the different parts of the machine; and in order that the working point may follow out the impreſſion already made, all the connecting parts or limbs of the machine muſt *be moved*, in different directions, and with different velocities. Force is neceſſary for thus changing the ſtate of all this matter, and frequently a very conſiderable force. Time muſt alſo elapſe before all this can be accompliſhed. This often conſumes, and really waſtes, a great part of the impelling power. Thus, in a crane worked by men walking in a wheel, it acquires motion by ſlow degrees; becauſe, in order to give ſufficient room for the action of the number of men or cattle that are neceſſary, a very capacious wheel muſt be employed, containing a great quantity of inert matter. All of this muſt be put in motion by a very moderate preponderance of the men. It accelerates ſlowly, and the load is raiſed. When it has attained the required height, all this matter, now in conſiderable motion, muſt be ſtopped. This cannot be done in an inſtant with a jolt, which would be very inconvenient, and even hurtful; it is therefore brought to reſt gradually. This alſo conſumes time; nay, the wheel muſt get a motion in the contrary direction, that the load may be lowered into the cart or lighter. This can only be accompliſhed by degrees. Then the tackle muſt be lowered down again for another load, which alſo muſt be done gradually. All this waſtes a great deal both of time and of force, and renders a walking wheel a very improper form for the firſt mover of a crane, or any machine whoſe uſe requires ſuch frequent changes of motion. The ſame thing obtains, although in a lower degree, in the ſteam engine, where the great beam and pump rods, ſometimes weighing very many tons, muſt be made to acquire a very briſk motion in oppoſite directions twice in every working ſtroke. It obtains, in a greater or a leſs degree, in all engines which have a reciprocating motion in any of their parts. Pump mills are of neceſſity ſubjected to this inconvenience. In the famous engine at Marly, about $\frac{19}{20}$ of the whole moving power of ſome of the water wheels is employed in giving a reciprocating motion to a ſet of rods and chains, which extend from the wheels to a ciſtern about three-fourths of a mile diſtant, where they work a ſet of pumps. This engine is, by ſuch injudicious conſtruction, a monument of magnificence, and the ſtruggle of ignorance with the unchangeable laws of Nature. In machines, all the parts of which continue the direction of their motions unchanged, the inertia of a great maſs of matter does no harm; but, on the contrary, contributes to the ſteadineſs of the motion, in ſpite of ſmall inequalities of power or reſiſtance, or unavoidable irregularities of force in the interior parts. But in all reciprocations, it is highly prejudicial to the performance; and therefore conſtructions which admit ſuch reciprocation without neceſſity, are avoided by all intelligent engineers. The mere copying artiſt, indeed, who derives all his knowledge from the common treatiſes of mechanics, will never ſuſpect ſuch imperfections, becauſe they do not occur in the ſtatical conſideration of machines.

10 And its friction.

Laſtly, no machine can move without a mutual rubbing of its parts, at all points of communication; ſuch as the teeth of wheelwork, the wipers and lifts, and the gudgeons of its different axes. In many machines, the ultimate taſk performed by the working point, is either friction, or very much reſembles it. This is the caſe in poliſhing mills, grinding mills, nay in boring mills, ſaw mills, and others. A knowledge of friction, in all its varieties, ſeems therefore abſolutely neceſſary, even for a moderate acquaintance with the principles of machinery. This is a very abſtruſe ſubject; and although a good deal of attention has been paid to it by ſome ingenious men, we do not think that a great deal has been added to our knowledge of it; nor do the experiments which have been made ſeem to us well calculated to lead us to a diſtinct knowledge of its nature and modifications. It has been conſidered chiefly with a view to diminiſh it as much as poſſible in the communicating parts of machinery, and to obtain ſome general rules for aſcertaining the quantity of what unavoidably remains. Mr Amontons, of the Royal Academy of Sciences at Paris, gave us, about the beginning of this century, the chief information that we have on the ſubject. He diſcovered, that the obſtruction which it gave to motion was very nearly proportional to the force by which the rubbing ſurfaces are preſſed together. Thus he found, that a ſmooth oaken board, laid on another ſmooth board of the ſame wood, requires a force nearly equal to one-third of what preſſes the ſurfaces together. Different ſubſtances required different proportions.

11
Meaſure of it by Amontons.

He alſo found, that neither the extent of the rubbing ſurfaces, nor the velocity of the motion, made any conſiderable variation on the obſtruction to motion. Theſe were curious and unexpected reſults. Subſequent obſervations have made ſeveral corrections neceſſary in all theſe propoſitions. This ſubject will be more particularly conſidered in another place; but ſince the deviations from Mr Amontons's rule are not very conſiderable, at leaſt in the caſes which occur in this general conſideration of machines, we ſhall make uſe of it in the mean time. It gives us a very eaſy method of eſtimating the effect of friction on machines. It is a certain proportion of the mutual preſſure of the rubbing ſurfaces, and therefore muſt vary in the ſame proportion with this preſſure. Now, we learn from the principles of ſtatics, that whatever preſſures are exerted on the impelled and working point of the machine, all the preſſures on its different parts have the ſame conſtant proportion to theſe, and vary as theſe vary: Therefore the whole friction of the machine varies in the ſame proportion. But farther, ſince it is found that the friction does not ſenſibly change with the velocity, the force which is juſt ſufficient to overcome the friction, and put the loaded machine in motion, muſt be very nearly the ſame with the force expended in overcoming the friction while the machine is moving with any velocity whatever, and performing work. Therefore if we deduct from the force which juſt puts the loaded machine in motion that part of it which balances the reaction of the impelled point occaſioned by the reſiſtance of the work, or which balances the reſiſtance of the work, the remainder is the part of the impelling power which is employed in overcoming the friction. If indeed the actual reſiſting preſſure of the work varies with the velocity of the working point, all the preſſures, and all the frictions in the different communicating parts of the machine, vary in the ſame proportion. But the law of this variation of working reſiſtance being known, the friction is again aſcertained.

We can now ſtate the dynamical equilibrium of forces in the working machine in two ways. We may either conſider the efficient impelling power as diminiſhed by all that portion which is expended in overcoming the friction, and which only prepares the machine for performing work, or we may conſider the impelling power as entire, and the work as increaſed by the friction of the machine; that is, we may ſuppoſe the machine without friction, and that it is loaded with a quantity of additional reſiſtance acting at the working point. Either of theſe methods will give the ſame reſult, and each has its advantages. We took the laſt method in the ſlight view which we took of this ſubject in the *Encycl.* art. ROTATION, n° 64. and ſhall therefore uſe it here.

Suppoſing now this previous knowledge of all theſe variable circumſtances which affect the motion of machines of the rotative kind, ſo that, for any momentary poſition of it while performing work, we know what are the preciſe preſſures acting at the impelled and working points, and the conſtruction of the machine, on which depend the friction, and the momentum of its inertia (expreſſed in the article ROTATION by $\int p r^2$); we are now in a condition to determine its motion, or at leaſt its momentary acceleration, competent to that poſition. Therefore,

12
Compoſition of the formula expreſſing the performance of a machine.

Let there be a rotative machine, ſo conſtructed, that while it is performing work, the velocity of its impelled point is to that of its working point as m to n. It is eaſy to demonſtrate, from the common principles of ſtatics, that if a ſimple wheel and axle be ſubſtituted for it, having the radius of the wheel to that of the axle in the ſame proportion of m to n, and having the ſame momentum of friction and inertia, and actuated by the ſame preſſures at the impelled and working points, then the velocities of theſe points will be preciſely the ſame as in the given machine.

Let p repreſent the intenſity (which may be meaſured by pounds weight) of the preſſure exerted in the moment at the impelled point; and r expreſs the preſſure exerted at the working point by the reſiſtance oppoſed by the work that is then performing. This may ariſe from the weight of a body to be raiſed, from the coheſion of timber to be ſawed, &c. Any of theſe reſiſtances may alſo be meaſured by pounds weight; becauſe we know, that a certain number of pounds hung on the ſaw of a ſaw mill, will juſt overcome this coheſion, or overcome it with any degree of ſuperiority. Therefore the impelling power p, and the reſiſtance r, however differing in kind, may be compared as mere preſſures.

Let x repreſent the quantity of inert matter which muſt be urged by the impelling power p, with the ſame velocity as the impelled point, in order that this preſſure p may really continue to be exerted on that point. Thus, if the impelling power is a quantity of water in the bucket of an overſhot wheel, acting by its weight, this weight cannot impel the wheel except by impelling the water. In this way, x may be conſidered as repreſenting the inertia of the impelling power, while p repreſents its preſſure on the machine. In like manner, let y repreſent the quantity of external inert matter which is really moved with the velocity of the working point in the execution of the taſk performed by the machine.

Whatever be the momentum of the inertia of the machine, we can always aſcertain what quantity of matter, attached to the impelled point, or the working point of the wheel and axle, will require the ſame force to give the wheel the ſame angular motion; that is, which ſhall have the ſame momentum of inertia. Let the quantity a, attached to the working point, give this momentum of inertia $a n^2$.

Laſtly, ſuppoſing that the wheel and axle have no friction, let f be ſuch a reſiſtance, that if applied to the working point, it ſhall give the ſame obſtruction as the friction of the machine, or require the ſame force at the impelled point to overcome it.

13 Angular motion of the machine. Theſe things being thus eſtabliſhed, the angular velocity of the wheel and axle, that is, the number of turns, or the portion of a turn, which it will make in a given time, will be proportional to the fraction $\frac{pm - \overline{r+f}\,n}{xm^2 + \overline{a+y}\,n^2}$. (I.)—See ROTATION, n° 64, &c. *Encycl.*

Since the whole turns together, the velocities of the different points are as their diſtances from the axis, and may be expreſſed by multiplying the common angular velocity by theſe diſtances. Therefore the above formula, multiplied by m or n, will give the velocity of the impelled or of the working point. Therefore,

14 Velocity of the impelled point. Velocity of impelled point $= \frac{pm^2 - \overline{r+f}\,mn}{xm^2 + \overline{a+y}\,n^2}$. (II.)

15 Velocity of the working point. Velocity of working point $= \frac{pmn - \overline{r+f}\,n^2}{xm^2 + \overline{a+y}\,n^2}$. (III.)

In order to obtain a clear conception of theſe velocities, we muſt compare them with motions with which we are well acquainted. The propoſition being univerſally true, we may take a caſe where gravity is the ſole power and reſiſtance; where, for example, p and r are the weights of the water in the bucket of a wheel, and in the tub that is raiſed by it. In this caſe, $p = x$, and $r = y$. We may alſo, for greater ſimplicity, ſuppoſe the machine without inertia and friction. The velocity of p is now $\frac{pm^2 - rmn}{pm^2 + rn^2}$.

16 Abſolute meaſure of them. Let g be the velocity which gravity generates in a ſecond. Then it will generate the velocity $g\dot{t}$ in the moment $\dot{t}$. Let $\dot{v}$ be the velocity generated during this moment in p, connected as it is with the wheel and axle, and with r. This connection produces a change of condition $= g\dot{t} - \dot{v}$. For, had it fallen freely, it would have acquired the velocity $g\dot{t}$, whereas it only acquires the velocity $\dot{v}$. In like manner, had r fallen freely, it would have acquired the velocity $g\dot{t}$. But, inſtead of this, it is raiſed with the velocity $\frac{n}{m}\dot{v}$. The change on it is therefore $= g\dot{t} + \frac{n}{m}\dot{v}$. Theſe changes of mechanical condition ariſe from their connection with the corporeal machine. Their preſſures on it bring into action its connecting forces, and each of the two external forces is in immediate equilibrium with the force exerted by the other. The force excited at the impelled point, by r acting at the working point, may be called the momentum or energy of r. Theſe energies are preciſely competent to the production of the changes which they really produce, and muſt therefore be conceived as having the ſame proportions. They are therefore equal and oppoſite, by the general laws *obſerved* in all actions of tangible matter; that is, they are ſuch as balance each other. Thus, and only thus, the remaining motions are what we obſerve them to be.

$$\text{That is, } p \times \overline{g\dot{t} - \dot{v}} \times m = r \times g\dot{t} + \frac{n}{m}\dot{v} \times n$$

$$\text{Or } pmg\dot{t} - pm\dot{v} = rng\dot{t} + r\frac{n^2}{m}\dot{v}$$

$$\text{Or } pm^2g\dot{t} - pm^2\dot{v} = rmng\dot{t} + rn^2\dot{v}$$

$$\text{Or } \overline{pm^2 - rmn} \times g\dot{t} = \overline{pm^2 + rn^2} \times \dot{v}$$

That is, $pm^2 + rn^2 : pm^2 - rmn = g\dot{t} : \dot{v}$

That is, *the denominator of the fraction, expreſſing the velocity of the impelled point, is to the numerator as the velocity which a heavy body would acquire in the moment* $\dot{t}$, *by falling freely, is to the velocity which the impelled point acquires in that moment.* The ſame thing is true of the velocity of the working point.

This reaſoning ſuffers no change from the more complicated nature of the general propoſition. Here the impelling power is ſtill p, but the matter to be accelerated by it at the working point is $a + y$, while its reaction, diminiſhing the impelling power, is only r. We have only to conſider, in this caſe, the velocity with which $a + y$ would fall freely when impelled, not by $a + y$, but only by r. The reſult would be the ſame; $g\dot{t}$ would ſtill be to $\dot{v}$ as the denominator of the ſame fraction to its numerator.

Thus have we diſcovered the momentary acceleration of our machine. It is evident, that if the preſſures p and r, and the friction and inertia of the machine, and the external matter, continue the ſame, the acceleration will continue the ſame; the motion of rotation will be uniformly accelerated, and $pm^2 + \overline{a+y}\,n^2$ will be to $pm^2 - \overline{r+f}\,mn$ as the ſpace s, through which a heavy body would fall in any given time t, is to the ſpace through which the impelled point will really have moved in the ſame time. In like manner, the ſpace through which the working point moves in the ſame time is $= \frac{pmn - \overline{r+f}\,n^2}{pm^2 + \overline{a+y}\,n^2}s$.

Thus are the motions of the working machine determined. We may illuſtrate it by a very ſimple example. Suppoſe a weight p of five pounds, deſcending from a pulley, and dragging up another weight r of three pounds on the other ſide. m and n are equal, and each may be called 1. The formula becomes $\frac{p-r}{p+r}s$, or $\frac{5-3}{5+3}s$, or $\frac{2}{8}, = \frac{1}{4}s$. Therefore, in a ſecond, the weight p will deſcend ¼th of 16 feet, or 4 feet; and will acquire the velocity of 8 feet per ſecond.

17 Performance of the machine. Having obtained a knowledge of the velocity of every point of the machine, we can eaſily aſcertain its performance. This depends on a combination of the quantity of reſiſtance that is overcome at the working point, and the velocity with which it is overcome. Thus, in raiſing water, it depends on the quantity (proportional to the weight) of water in the bucket or pump, and the velocity with which it is lifted up. This will be had by multiplying the third formula by r, or by $rg\dot{t}$, or by rs. Therefore we obtain this expreſſion,

$$\text{Work done} = \frac{pmrn - \overline{r+f}\,rn^2}{pm^2 + \overline{a+y}\,n^2}g\dot{t}. \quad \text{(IV.)}$$

Such is the general expreſſion of the momentary performance of the machine, including every circumſtance which can affect it. But a variation of thoſe circumſtances produces great changes in the reſults. Theſe muſt be diſtinctly noticed.

Cor. 1. If $pmrn$ be equal to $\overline{r+f}\,rn^2$, there will be no work done, becauſe the numerator of the fraction is annihilated. There is then no unbalanced force, and the natural power is only able to balance the preſſure propagated from the working point to the impelled point.

2. In like manner, if $n = o$, no work is done altho' the machine turns round. The working point has no motion. For the ſame reaſon, if m be infinitely great, although there is a great prevalence of impelling momentum, there will not be any ſenſible performance during a finite time. For the velocity which p can impreſs is a finite quantity, and the impelled point cannot move faſter than x would be moved by it if detached from the machine. Now when the infinitely remote impelled point is moved through any finite ſpace, the motion of the working point muſt be infinitely leſs, or nothing, and no work will be done.

Remark. We ſee that there are two values of n, viz. v, and $m \times \frac{p}{r}$, which give no performance. But in all other proportions of m and n ſome work is done. Therefore, as we gradually vary the proportion of m to n, we obtain a ſeries of values expreſſing the performance, which muſt gradually increaſe from nothing, and then decreaſe to nothing. There muſt therefore be ſome proportion of m to n, depending on the proportion of p to $\overline{r+f}$, and of x to $\overline{a+y}$, which will give the greateſt poſſible value of the performance. And, on the other hand, if the proportion of m to n be already determined by the conſtruction of the machine already erected, there muſt be ſome proportion of p to $\overline{r+f}$, and of x to $\overline{a+y}$, by which the greateſt performance of the machine may be enſured. It is evident, that the determination of theſe two proportions is of the utmoſt importance to the improvement of machines. The well informed reader will pardon us for endeavouring to make this appear more forcibly to thoſe who are leſs inſtructed, by means of ſome very ſimple examples of the firſt principle.

Suppoſe that we have a ſtream of water affording three tons per minute, and that we want to drain a pit which receives one ton per minute, and that this is to be done by a wheel and axle? We wiſh to know the beſt proportion of their diameters m and n. Let m be taken $= 6$; and ſuppoſe,

1. That $n = 5$.

Then $\frac{pmrn - r^2n^2}{pm^2 + rn^2} = \frac{3.6.1.5 - 1.25}{3.36 + 1.36}, = \frac{65}{133}, = 0{,}4887$

2. Let n be $= 6$. The formula is $= 0{,}5$.

3. Let $n = 7$. The formula is $= 0{,}49045$. Hence we find, that the performance is greater when n is 6, than when it is either 5 or 7.

As an example of the ſecond principle, ſuppoſe the machine a ſimple pulley, and let p be 10.

1. Let r be $= 3$. The formula is $\frac{10 \times 3 - 9}{10 + 3}, = \frac{21}{13}, = 1{,}6154$.

2. Let r be $= 4$. The formula is $= \frac{10 \times 4 - 16}{10 + 4}, = \frac{24}{14}, = 1{,}7143$.

3. Let r be $= 5$. The formula is $= \frac{10 \times 5 - 25}{10 + 5}, = \frac{25}{15}, = 1{,}6666$. Here it appears, that more work is done when r is 4 than when it is 5 or 3.

It muſt therefore be allowed to be one of the moſt important problems in practical mechanics to determine that conſtruction by which a given power ſhall overcome a given reſiſtance with the greateſt advantage, and the proportion of work which ſhould be given to a machine already conſtructed ſo as to gain a ſimilar end.

18 Proportion of the machine which gives the greateſt work.

I. The general determination of the firſt queſtion has but little difficulty. We muſt conſider n as the variable magnitude in the formula $\frac{pmrn - \overline{r+f}\,rn^2}{pm^2 + \overline{a+y}\,n^2}$, which expreſſes the work done; and find its value when the formula is a maximum. Taking this method, we ſhall find that the formula IV. is a maximum when n is

$$= m\,\frac{\sqrt{x^2(r+f)^2 + p^2x(a+y)} - x(r+f)}{p(a+y)}.$$

This expreſſion of the performance, in its beſt ſtate, appears pretty complex; but it becomes much more ſimple in all the particular applications of it, as the circumſtances of the caſe occur in practice.

We have obtained a value of n expreſſed in parts of m If we ſubſtitute this for n in the third formula, we obtain the greateſt velocity with which the reſiſtance r, connected with the inertia y, can be overcome by the power p, connected with the inertia x, by the intervention of a machine, whoſe momentum of inertia and friction are an^2 and fn. This is $= \frac{\overline{r+f}}{\overline{2a+y}} \times \left(\sqrt{\frac{p^2\,\overline{a+y}}{\overline{r+f}^2\,x} + 1} - 1\right) g\,i$. This expreſſes the velocity of the working point in feet per ſecond, and therefore the actual performance of the machine.

But the proper proportion of m to n, aſcertained by this proceſs, varies exceedingly, according to the nature both of the impelling power, and of the work to be performed by the machine.

1. It frequently happens that the work exerts no contrary ſtrain on the machine, and conſiſts merely in impelling a body which reſiſts only by its inertia. This is the caſe in urging round a millſtone or a heavy fly; in urging a body along a horizontal plane, &c. In this caſe r does not enter into the formula, which now becomes $m \times \frac{\sqrt{x^2f^2 + p^2x(a+y)} - xf}{p(a+y)}$. If the friction be inſignificant we may take $n = m\sqrt{\frac{p^2x(a+y)}{p^2(a+y)^2}} = m\sqrt{\frac{x}{a+y}}$. The velocity of the working point is nearly $= \frac{p}{2\sqrt{x\,\overline{a+y}}}$. In this caſe, it will be found that the velocity acquired at the end of a given time will be nearly in the proportion of the power applied to the machine.

2. On the other hand, and more frequently, the inertia of the external matter which muſt be moved in performing the work need not be regarded. Thus, in the grinding of grain, ſawing of timber, boring of cylinders, &c. the quantity of motion communicated to the flour, to the ſaw duſt, &c. is too inſignificant to be taken into the account. In this caſe, y vaniſhes from the formula, which becomes extremely ſimple when the friction and inertia of the machine are inconſiderable. We

ſhall not be far from the truth if we make *m* to *n* as $2r$ to p, or $n = m \times \frac{p}{2r+f}$. In this caſe, the velocity of the working point is $\frac{p^2}{4x(r+f) + \frac{ap^2}{4(r+f)}}$.

But it is rare that machines of this kind have a ſmall inertia. They are generally very ponderous and powerful; and the force which is neceſſary for generating even a very moderate motion in the unloaded machine (that is, unloaded with any work), bears a great proportion to the force neceſſary for overcoming the reſiſtance oppoſed by the work. The formula muſt therefore be uſed in all the terms, becauſe a is joined with y. It would have been ſimpler in this particular, had a been joined with x in the expreſſion of the angular velocity.

3. In ſome caſes we need not attend to the inertia of the power, as in the ſteam engine. In this caſe, if taken ſtrictly, n appears to have no value, becauſe x is a factor of every term of the numerator. But the formula gives this general indication, that the more inſignificant the inertia of the moving power is ſuppoſed, the larger ſhould m be in proportion to n; provided always, that the impelling power is not, by its nature, greatly diminiſhed, by giving ſo great a velocity to the impelled point. This circumſtance will be particularly conſidered afterwards.

4. If the inertia of the power and the reſiſtance be proportional to their preſſures, as when the impelling power is water lying in the buckets of an overſhot wheel, and the work is the raiſing of water, minerals, or other heavy body, acting *only* by its weight; then p and r may be ſubſtituted for x and y, and the formula expreſſing the value of n, when the performance is a maximum, becomes

$$n = m\frac{\sqrt{p^2\times\overline{r+f}^2+p^3\times\overline{a+r}}-p\times\overline{r+f}}{p\times\overline{a+r}}.$$

If, in this caſe, the inertia and friction of the machine may be diſregarded, as may often be done in pulleys, we have

$$n = m\sqrt{\frac{p}{r}+1}-1,$$

If we make m the unit of the radii, and r the unit of force, we have

$$n = \sqrt{p+1}-1, \text{ in parts of } m = 1.$$

Or, making $p = 1$, we have $n = \sqrt{\frac{1}{r}+1}-1$.

Theſe very ſimple expreſſions are of conſiderable uſe, even in caſes where the inertia of the machine is very conſiderable, provided that it have no reciprocating motions. A ſimple wheel and axle, or a train of good wheelwork, have very moderate friction. The general reſults, therefore, which even very unlettered readers can deduce from theſe ſimple formulæ, will give notions that are uſeful in the caſes which they cannot ſo thoroughly comprehend. Some ſervice of this kind may be derived from the following little table of the beſt proportions of m to n, correſponding to the proportions of the power furniſhed to the engineer, and the reſiſtance which muſt be overcome by it. The quantity r is always $= 10$, and $m = 1$.

p	*n*	*p*	*n*
1	0,0488	10	0,4142
2	0,0954	20	0,7321
3	0,1402	30	1,
4	0,1832	40	1,2362
5	0,2246	50	1,4495
6	0,2649	60	1,6457
7	0,3038	70	1,8284
8	0,3416	80	2,
9	0,3784	90	2,1623
10	0,4142	100	2,3166

This muſt ſuffice for a very general view of the firſt problem.

19 Beſt proportion of the power and work.

II. The next queſtion is not leſs momentous, namely, to determine for a machine of a given conſtruction that proportion of the reſiſtance at the working point to the impelling power which will enſure the greateſt performance of the machine; that is, the proportion of m to n being given, to find the beſt proportion of p to r.

This is a much more complicated problem than the other; for here we have to attend to the variations both of the preſſures p and r, and alſo of the external matters x and y, which are generally connected with them. It will not be ſufficient therefore to treat the queſtion by the uſual fluxionary proceſs for determining the maximum, in which x is conſidered as the only varying quantity. We muſt, in this curſory diſcuſſion, reſt ſatisfied with a comprehenſion of the circumſtances which moſt generally prevail in practice.

It muſt either happen, that when r changes, there is no change (that is, of moment) in the maſs of external matter which muſt be moved in performing the work, or that there is alſo a change in this circumſtance. If no change happens, the denominator of the fourth formula, expreſſing the performance, remains the ſame; and then the formula attains a maximum when the numerator $prmn - \overline{r+f}\,rn^2$ is a maximum. Alſo, we may include f without complicating the proceſs, by the conſideration, that f is always in nearly the ſame ratio to r; and therefore $r+f$ may be conſidered as a certain multiple of r, ſuch as br. We may therefore omit f in the fluxionary equations for obtaining the maximum, and then, in computing the performance, divide the whole by b. Thus if the whole friction be $\frac{1}{20}$th of the reſiſting preſſure r, we have $r+f = \frac{21}{20}$ of r, and $b = \frac{21}{20}$. Having aſcertained the beſt value for r, we put this in its place in the fourth formula, and take $\frac{20}{21}$ of this for the performance. This will never differ much from the truth.

This proceſs gives us $pmn = 2n^2r$, and $r = \frac{pmn}{2n^2}$, $= \frac{pm}{2n}$; and if we farther ſimplify the proceſs, by making $p = 1$, and $m = 1$, we have $r = \frac{1}{2n}$; a moſt ſimple expreſſion, directing us to make the reſiſtance one half of what would balance the impelling power by the intervention of the machine.

This will evidently apply to many very important caſes, namely, to all thoſe in which the matter put in motion by the working point is but trifling.

But it alſo happens in many important caſes, that the change is at leaſt equally conſiderable in the inertia of the work. In this caſe it is very difficult to obtain a general ſolution. But we can hardly imagine ſuch a change, without ſuppoſing that the inertia of the work varies in the ſame proportion as the preſſure excited by it at the working point of the machine; for ſince r continues the ſame in kind, it can rarely change but by a proportional change of the matter with which it is connected. Yet ſome very important caſes occur where this does not happen. Such is a machine which forces water along a long main pipe. The reſiſtance to motion and the quantity of water do not follow nearly the ſame ratio. But in the caſes in which this ratio is obſerved, we may repreſent y by any multiple $b\,r$ of r, which the caſe in hand gives us; b being a number, integer, or fractional. In the farther treatment of this caſe, we think it more convenient to free r from all other combinations; and inſtead of ſuppoſing the force f (which we made equivalent with the friction of the machine) to be applied at the working point, we may apply it at the impelled point, making the effective power $q=p-f$. For the ſame reaſons, inſtead of making the momentum of the machine's inertia $= a n^2$, we may make it $a m^2$, and make $a+x=z$. Now, ſuppoſing q, or $p-f$, $=1$, and alſo $m=1$, our formula expreſſing the performance becomes $\frac{r n - r^2 n^2}{z + b r n^2}$. This is a maximum when

$$r = \frac{\sqrt{z^2 + z b n} - z}{b n^2}.$$

Cor. 1. If the inertia of the work is always equal to its preſſure, as when the work conſiſts wholly in raiſing a weight, ſuch as drawing water, &c. then $b=1$, and the formula for the maximum performance becomes

$$r = \frac{\sqrt{z n + z^2} - z}{n^2}.$$

2. If the inertia of the impelling power is alſo the ſame with its preſſure, and if we may neglect the inertia and friction of the machine, the formula becomes

$$r = \frac{\sqrt{n+1} - 1}{n^2}$$

Example. Let the machine be a common pulley, ſo that the radii m and n are equal, and therefore $n=1$. Then, $r = \frac{\sqrt{1+1} - 1}{1}, = \sqrt{2} - 1, = 0{,}4142$, &c. more than $\frac{2}{5}$ths of what would balance it.

Here follows a ſeries of the beſt values of r, correſponding to different values of n. m and p are each $=1$. The numbers in the laſt column have the ſame proportion to 1 which r has to the reſiſtance which will balance p.

$n = \frac{1}{4}$	$r =$ 1,8885	0,4724 to 1
$\frac{1}{3}$	1,3928	0,4639
$\frac{1}{2}$	0,8986	0,4493
1	0,4142	0,4142
2	0,1830	0,3660
3	0,1111	0,3333
4	0,0772	0,3088

From what has now been eſtabliſhed, we ſee with ſufficient evidence the importance of the higher mathematics to the ſcience of mechanics. If the velocities of the impelled and working points of an engine are not properly adjuſted to the preſſures, the inertia, and the friction of the machine, we do not derive all the advantages which we might from our ſituation. Hence alſo we learn the falſity of the maxim which has been received as well founded, that the augmentation of intenſity of any force, by applying it to the long arm of a lever, is always fully compenſated by a loſs of time; or, as it is uſually expreſſed, "what we gain by a machine in force we loſe in time." If the proportion of m to n is well choſen, we ſhall find that the work done, when it reſiſts by its inertia only, increaſes nearly in the proportion of the power employed; whereas when the inertia of the work is but a ſmall part of the reſiſtance, it increaſes nearly in the duplicate ratio of the power employed.

General but erroneous maxim.

It was remarked, in the ſetting out in the preſent problem, that the formulæ do not immediately expreſs the velocity of any point of the machine, but its momentary acceleration. But this is enough for our purpoſe; becauſe, when the momentary acceleration is a maximum, the velocity acquired, and the ſpace deſcribed, in any given time, is alſo a maximum. We alſo ſhewed how the real velocities, and the ſpaces deſcribed, may be aſcertained in known meaſures. We may ſay in general, that if g repreſent the preſſure of gravity on any maſs of matter w, then $\frac{g}{w}$ is to $\frac{p m n - \overline{r+f}\, n}{a m^2 + \overline{a+y}\, n^2}$ as 16 feet to the ſpace deſcribed in a ſecond by the working point in a ſecond, or as 32 feet per ſecond is to the velocity acquired in that time.

20
Cauſes why machines do not continually accelerate.

A remark now remains to be made, which is of the greateſt conſequence, and gives an unexpected turn to the whole of the preceding doctrines. It appears, from all that has been ſaid, that the motion of a machine muſt be uniformly accelerated, and that any point will deſcribe ſpaces proportional to the ſquares of the times; for while the preſſures, friction, and momentum of inertia remain the ſame, the momentary acceleration muſt alſo be invariable. But this ſeems contrary to all experience. Such machines as are properly conſtructed, and work without jolts, are obſerved to quicken their pace for a few ſeconds after ſtarting; but all of them, in a very moderate time, acquire a motion that is ſenſibly uniform. Is our theory erroneous, or what are the circumſtances which remain to be conſidered, in order to make it agree with obſervation? The ſcience of machines is imperfect, till we have explained the cauſes of this deviation from the theory of uniform acceleration.

Theſe cauſes are various.

1. Increaſe of friction.

1. In ſome caſes, every increaſe of velocity of the machine produces an increaſe of friction in all its communicating parts. By theſe means, the accelerating force, which is $p m - \overline{r+f}\, n$, or $p - f m - r n$, is diminiſhed, and conſequently the acceleration is diminiſhed. But it ſeldom happens that friction takes away or employs the whole accelerating force. We are not yet well inſtructed in the nature of friction. Moſt of the kinds of friction which obtain in the communicating parts of machines, are ſuch as do not ſenſibly increaſe by an increaſe of velocity; ſome of them really diminiſh. Yet even the moſt accurately conſtructed machines, unloaded with work, attain a motion that is ſenſibly uniform. If we take off the pallets from a pendulum-

dulum clock, and allow it to run down amain, it accelerates for a while, but in a very moderate time it acquires an uniform motion. So does a common kitchen jack. Theſe two machines ſeem to bid the faireſt of any for an uniformly accelerated motion; for their impelling power acts with the utmoſt uniformity. There is ſomething yet unexplained in the nature of friction, which takes away ſome of this acceleration.

2. Reſiſtance of air.

But the chief cauſe of its ceſſation in theſe two inſtances, and others *of very rapid motion*, is the reſiſtance of the air. This ariſes from the motion which is communicated to the air diſplaced by the ſwift moving parts of the machine. At firſt it is very ſmall; but it increaſes nearly in the duplicate ratio of the velocity (ſee *Resistance of Fluids*, Encycl.) Thus r increaſes continually; and, in a certain ſtate of motion, $\overline{r+fn}$ becomes equal to pm. Whenever this happens, the accelerating power is at an end. The acceleration alſo ceaſes; and the machine is in a ſtate of dynamical equilibrium; not at reſt, but moving uniformly, and performing work.

3. Increaſe of reſiſtance very imperfectly known.

Still, however, this is not one of the general cauſes of the uniform motion attained by working engines. Rarely is the motion of their parts ſo rapid, as to occaſion any great reſiſtance from the air. But in the moſt frequent employments of machines, every increaſe of velocity is accompanied by an increaſe of reſiſtance from the work performed. This occurs at once to the imagination; and few perſons think of inquiring farther for a reaſon. But there is perhaps no part of mechanics that is more imperfectly underſtood, even in our preſent improved ſtate of mechanical ſcience. In many kinds of work, it is very difficult to ſtate what increaſe of labour is required in order to perform the work with twice or thrice the ſpeed. In grinding corn, for inſtance, we are almoſt entirely ignorant of this matter. It is very certain, that twice the force is not neceſſary for making the mill grind twice as faſt, nor even for making it grind twice as much grain equally well. It is not eaſy to bring this operation under mathematical treatment; but we have conſidered it with ſome attention, and we imagine that a very great improvement may ſtill be made in the conſtruction of griſt mills, founded on the law of variation of the reſiſtance to the operation of grinding, and a ſcientific adjuſtment of m to n, in conſequence of our knowledge of this law. We may make a ſimilar obſervation on many other kinds of work performed by machines. In none of thoſe works where the inertia of the work is inconſiderable, are we well acquainted with the real mechanical proceſs in performing it. This is the caſe in ſawing mills, boring mills, rolling mills, ſlitting mills, and many others, where the work conſiſts in overcoming the ſtrong coheſion of a ſmall quantity of matter. In ſawing timber (which is the moſt eaſily underſtood of all theſe operations), if the ſaw move with a double velocity, it is very difficult to ſay how much the actual reſiſting preſſure on the teeth of the ſaw is increaſed. Twice the number of fibres are neceſſarily torn aſunder during the ſame time, becauſe the ſame number are torn by one deſcent of the ſaw, and it makes that ſtroke in half the time. But it is very uncertain whether the reſiſtance is double on this account; becauſe if each fibre be ſuppoſed to have the ſame tenacity in both caſes, it reſiſts with this tenacity only for half the time. The parts of bodies reſiſt a ſimilar change of condition in different manners; and there is another difference in their reſiſtance of different changes—the reſiſtance of red hot iron under the roller may vary at a very different rate from that of its reſiſtance to the cutting tool. The reſiſtance of the ſpindles of a cotton mill, ariſing partly from friction, partly from the inertia of the heaped bobins, and partly from the reſiſtance of the air, is ſtill more complicated, and it may be difficult to learn its law. The only caſe in which we can judge with ſome preciſion is, when the inertia of matter, or a conſtant preſſure like that of gravity, conſtitutes the chief reſiſtance. Thus in a mill employed to raiſe water by a chain of buckets, the reſiſtance proceeds from the inertia only of the water. The buckets are moving with a certain velocity, and the loweſt of them takes hold of a quantity of water lying at reſt in the pit, and drags it into motion with its acquired velocity. The force required for generating this motion on the quieſcent water muſt be double or triple, when the velocity that muſt be given to it is ſo. This abſorbs the overplus of the impelling power, by which that power exceeds what is neceſſary for balancing the weight of the water contained in all the aſcending buckets. This is a certain determinate quantity which does not change; for in the ſame inſtant that a new bucket of water is forced into motion below, and its weight added to that of the aſcending buckets, an equal bucket is emptied of its water at top. The aſcending buckets require only to be balanced, and they then *continue* to aſcend, with any velocity already acquired. While the machine moves ſlow, the motion impreſſed on the new bucket of water is not ſufficient to abſorb all the overplus of impelling power. The quantity not abſorbed accelerates the machine, and the next bucket muſt produce more motion in the water which it takes up. This conſumes more of the overplus. This goes on till no overplus of power is left, and the machine accelerates no more. The complete performance of the machine now is, that "a certain quantity of water, formerly at reſt, is now moving with a certain velocity." Our engineers conſider it differently; "as a certain *weight* of water lifted up." But while the machine is thus moving uniformly, it is really not doing ſo much as before; that is, it is not exerting ſuch great preſſures as before the motion was rendered uniform: for at that time there was a preſſure at the working point equal to the weight of all the water in the aſcending buckets; and alſo an overplus of preſſure, by which the whole was accelerated. In the ſtate of uniform motion, the preſſure is no more than juſt balances the weight of the aſcending chain. We ſhall learn by and bye how the preſſures have been diminiſhing, although the mill has been accelerating; a thing that ſeems a paradox.

In this inſtance, then, we ſee clearly, why a machine muſt attain a uniform motion. A pumping machine gives us the ſame opportunity, but in a manner ſo different as to require explanation. The piſton may be ſuppoſed at the very ſurface of the pit water, and the impelling power may be leſs than will ſupport a column in the pipe as high as can be raiſed by the preſſure of the atmoſphere. Suppoſe the impelling power to be the water lying in the buckets of an overſhot wheel.

Let this water be laid into the buckets by a very ſmall ſtream. It will fill the buckets very ſlowly; and as this gives them a preponderance, the mill loſes its balance, the wheel begins to move, and the piſton to riſe, and the water to follow it. The water may be delivered on the wheel drop by drop; the piſton will riſe by inſenſible degrees, always ſtanding ſtill again as ſoon as the atmoſpheric preſſure on it juſt balances the water on the wheel. The water in the riſing pipe is always a balance to the preſſure of the atmoſphere on the ciſtern; therefore the preſſure of the atmoſphere on the piſton (which is the r in our formula) is equal to the weight of this water. Our pump-makers therefore (calling themſelves engineers) ſay, that the weight of water in the pipe balances the water on the wheel. It does not balance it, nor is it raiſed by the wheel, but by the atmoſphere; but it ſerves us at preſent for a meaſure of the power of the wheel. At laſt, all the buckets of the wheel are full, and the water is (for example) 25 feet high in the pipe. Now let the ſtream of water run its full quantity. It will only run over from bucket to bucket, and run off at the bottom of the wheel; but the mill will not move, and no work will be performed. (N. B. We are here excluding all impulſe or ſtroke on the buckets, and ſuppoſing the water to act only by its weight.) But now let all be emptied again, and let the water be delivered on the wheel in its full quantity at the firſt. The wheel will immediately acquire a preponderancy, which will *greatly* exceed the firſt ſmall preſſure of the atmoſphere on the piſton. It will therefore accelerate the piſton, overcoming the preſſure of the air with great velocity. The piſton riſes faſt; the water follows it, by the preſſure of the atmoſphere; and when it attains the former utmoſt height, it attains it with a conſiderable velocity. If allowed to run off there, it will *continue* to run off with that velocity; becauſe there is the ſame quantity of water preſſing round the wheel as before, and therefore enough to balance the preſſure of the atmoſphere on the piſton. The preſſure of the ſame atmoſphere on the water in the ciſtern, raiſed the water in the pipe with this velocity; therefore it will continue to do ſo, and the mill will deliver water by the pump with this velocity, although there is no more preſſure acting on it than before, when the water ran to waſte, doing no work whatever.

This mode of action is extremely different from the former example. The mill is not acting againſt the inertia y of the water to be moved, but againſt the preſſure r of the atmoſphere on the piſton. The preſſure of the ſame atmoſphere on the ciſtern is employed againſt the inertia of the water in the pipe; and the uſe of the mill is to *give occaſion*, by raiſing the piſton, to the exertion of this atmoſpherical preſſure, which is the real raiſer of the water. The maxim of conſtruction, and the proper adjuſtment of m to n in this caſe, are different from the former; and we ſhould run the riſk of making an imperfect engine were we to confound them.

We muſt mention another caſe of a pumping mill, ſeemingly the ſame with this, but eſſentially different. Suppoſe the pipe of this pump to reach 30 feet below the ſurface of the pit water, and that the piſton is at the very bottom of it. Suppoſe alſo, that the wheel buckets, when filled with water, only enable it to *ſupport* 25 feet of water in the riſing pipe. Let the water be delivered into the wheel drop by drop. The wheel will gradually preponderate; the piſton will gradually riſe, lifting the water above it, ſuſtaining a preſſure of water which gradually increaſes. At laſt, the water in the pump is 25 feet higher than that in the ciſtern; the wheel is full and running to waſte; but no work is performed. Let all be emptied, and now let the water come to the wheel in its full ſtream, but without impulſe. The piſton will lift the water briſkly, bring it to 25 feet high with a conſiderable velocity, and the mill will now raiſe it with this velocity. In this example, the mill is the immediate agent in raiſing the water; but, in this caſe alſo, its ultimate office is not overcoming inertia, but overcoming preſſure. It was the overplus of power only that was employed in overcoming inertia, while accelerating the water in the riſing pipe, in order to give it the neceſſary velocity for a continued diſcharge.

21 Theſe and ſimilar examples ſhew the great difference between the ſtatical and dynamical equilibrium of machines, and the neceſſity of a ſcientific attention by all who wiſh to improve practical mechanics. Without this, and even a pretty refined attention, we cannot ſee the connection between a copious ſupply of water to the bucket wheel and a plentiful diſcharge by the pump. We believe, that the greateſt part of thoſe employed in erecting machines conceive it as owing to the greater weight of water impelling the wheel with greater force; but we ſee that there is no difference in the preſſures on the mill at reſt, and the mill doing its work ſteadily and uniformly, with any velocity, however great. Without keeping the notions of that part of the impelling power which ſupports diſtinct from that of the part which accelerates, we ſhall never have a clear conception of the operation of machines, or of mechanical power in general. We cannot derive all the advantages of our natural powers, without knowing how our machine employs the preſſure excited by it at the working point; that is, without perceiving in what caſes it is oppoſed to inertia, and in what to the mechanical properties of tangible matter. This only can inform us at what rate the reſiſtance varies by a change of velocity; and when it happens that this augmentation, neceſſarily accompanied by an augmentation of all the frictions, and the reſiſtance of the air, is in equilibrio with the whole of the impelling power, and all acceleration is at an end.

22 The chief cauſe is a real diminution of power.

Laſtly, another chief cauſe of the finally uniform motion of machines is, that, in moſt caſes, an increaſe of velocity produces a real diminution of impelling power. We hardly know any exception to this beſides the employment of *one* deſcending weight as a power or firſt mover. Moſt of the powers which we employ reſide in bodies external to the machine; and theſe bodies muſt be put in motion, and continued in that motion, in order to continue their preſſure on the impelled point. Frequently a great part of the power is employed in giving this neceſſary motion to the external matter, and the remainder only is employed in preſſing forward the machine. We mentioned a remarkable inſtance of this in the operation of thraſhing. Now, the power thus employed muſt increaſe in proportion to the motion required; that is, in proportion to the velocity of the impelled point; what remains, urging forward the machine, is therefore diminiſhed. The acceleration is therefore diminiſhed, and may ceaſe. At *laſt* the actual preſſure is ſo much diminiſhed, that it is no more than what is neceſſary for overcoming the increaſed reſiſtance of the work, the increaſed friction. The machine therefore accelerates no more, but moves uniformly.

This cauſe very general.

This cauſe of the diminution of power by an increaſe of velocity, obtains in all caſes where the ſtrength of animals, of ſprings, the force of fired gunpowder, &c. is exerted. In ſome caſes, the viſible effect is not very conſiderable; as in the employment of a ſtrong ſpring, the force of gunpowder, and a few others. In the action of animals, this defalcation of power is very great when the velocity is conſiderable. Nay, even in the action of gravity, although it acts as ſtrongly on a body in rapid motion as on one at reſt, yet when gravity is not the immediate agent, but acts by the intervention of a body in which it reſides, the neceſſity of previouſly moving this body frequently diminiſhes the acceleration which it would otherwiſe produce. Thus, in an overſhot wheel, if the water be delivered into the bucket with a velocity (eſtimated in the direction of the part of the wheel into which it is delivered) leſs than that of the rim of the wheel, it muſt retard the motion; for it muſt be immediately dragged into that motion; that is, part of the accelerating overplus, already acting on the wheel, muſt be employed in accelerating this new bucket of water, and this muſt leſſen the general acceleration of the machine. Hence we learn, that the water muſt be delivered on the wheel with a velocity that is at leaſt not leſs than that of the wheel's motion.

It obtains in all machines actuated by impulſion,

The caſe in which we ſee this diminution of power on machines moſt diſtinctly is, when water or wind, acting by impulſe alone, is our moving power. Since the mutual impulſes of bodies depend entirely on their relative motions (ſee IMPULSION, *Suppl.*), it follows, that when the velocity of the impelled point is augmented, the impulſion, or effective preſſure, muſt be diminiſhed. Nay, this velocity may be ſo increaſed, that there ſhall be no relative motion, and therefore no impulſion. If the floats of an underſhot wheel be moving with the velocity of the ſtream, they remain conjoined in their progreſs, but without any mutual action. Therefore, when an underſhot wheel is ſet into a running water, the firſt impulſions are ſtrong, and accelerate the wheel. This diminiſhes the next impulſion and acceleration: but the wheel is ſtill impelled and accelerated; leſs and leſs in every ſucceeding moment, as it moves faſter; by and bye, the acceleration becomes inſenſible, and the wheel appears to attain a motion which is perfectly uniform. This requires a very long time, or rather it is never attained, and we only cannot diſcern the very ſmall additions which are ſtill made to the velocity. All this happens generally after a very moderate time, by reaſon of various other obſtructions.

Or by the force of animals.

Animal action is ſubject to the ſame variation. We know, that there is a certain rate at which a horſe can run, exhauſting or employing his whole ſtrength. If he be made to drag any the ſmalleſt load after him, he muſt employ part of his force on it, and his ſpeed will be checked. The more he is loaded with a draught, the ſlower he will run, ſtill employing all his ſtrength. The draught may be increaſed till he is reduced to a trot, to a walk, nay, till he is unable to draw it. Now, juſt inverting this proceſs, we ſee, that there is a certain ſtrain which will ſufficiently tire the horſe without ſtirring from the ſpot, but which he could continue to exert for hours. This is greater than the load that he can juſt crawl along with, employing his ſtrength as much as would be prudent to continue from day to day. And, in like manner, every leſſer draught has a correſponding rate, at which the horſe, employing his whole working ſtrength, can continue to draw at during the working hours of a day. At ſetting out, he pulls harder, and accelerates it. Following his pull, he walks faſter, and therefore pulls leſs (becauſe we are ſtill ſuppoſing him to employ his whole working ſtrength). At laſt he attains that ſpeed which occupies his whole ſtrength in merely continuing the pull. Other animals act in a ſimilar manner; and it becomes a general rule, that the preſſure actually exerted on the impelled point of a machine diminiſhes as its velocity increaſes.

23
We muſt diſtinguiſh between the power expended and the power employed.

From the concurrence of ſo many facts, we perceive that we muſt be careful to diſtinguiſh between the quantity of power expended, and the quantity that is uſefully employed, which muſt be meaſured ſolely by the preſſure exerted on the machine. When a weight of five pounds is employed to drag up a weight of three pounds by means of a thread over a pulley, it deſcends, with a motion uniformly accelerated, four feet in the firſt ſecond. Mr Smeaton would call this an expenditure of a mechanical power 20. The weight three pounds is raiſed four feet. Mr Smeaton would call this a mechanical effect 12. Therefore the effect produced is not adequate to the power expended. But the fact is, that the preſſure, ſtrain, or mechanical power really exerted in this experiment, is neither five nor three pounds; the five pound weight would have fallen 16 feet, but it falls only 4. A force has therefore acted on it ſufficient to make it deſcribe 12 feet in a ſecond, with a uniformly accelerated motion; for it has counteracted ſo much of its weight. The thread was ſtrained with a force equal to $3\frac{3}{4}$ pounds, or $\frac{3}{4}$ths of 5 pounds. In like manner, the three pound weight would have fallen 16 feet; but it was raiſed 4 feet. Here was a change preciſely equal to the other. A force of $3\frac{3}{4}$ pounds, acting on a maſs whoſe matter is only 3, will, in a ſecond, cauſe it to deſcribe 20 feet with a uniformly accelerated motion. Now, 5 × 12, and 3 × 20, give the ſame product 60. And thus we ſee, that the quantity of motion extinguiſhed or produced, and not the product of the weight and height, is the true unequivocal meaſure of mechanical power really expended, or the mechanical effect really produced; and that theſe two are always equal and oppoſite. At the ſame time, Mr Smeaton's theorem merits the attention of engineers; becauſe it generally meaſures the opportunities that we have for procuring the exertion of power. In ſome ſenſe Mr Smeaton may ſay, that the quantity of water multiplied by the height from which it deſcends in working our machines, is the meaſure of the power expended; becauſe we muſt raiſe this quantity to the dam again, in order to have the ſame uſe of it. It is expended, but not employed; for the water, at leaving the wheel, is ſtill able to do ſomething.

24.

It requires but little conſideration to be ſenſible, that the preceding account of the ceſſation of accelerated motion in our principal machines, muſt introduce different maxims of conſtruction from thoſe which were expreſsly adapted to this acceleration; or rather, which proceeded on the erroneous ſuppoſition of the conſtancy of the impelling power and the reſiſtance. The examination of this point has brought into view the fundamental principle of working machines, namely, the perfect equilibrium which takes place between the impelling power and the ſimultaneous reſiſtance. It may be expreſſed thus:

Firſt principle of working machines.

The force required for preſerving a machine in uniform motion, with any velocity whatever, is that which is neceſſary for balancing the reſiſtance then actually exerted on the working point of the machine. We ſaw this diſtinctly in the inſtance of the two weights acting againſt each other by the intervention of a thread over a fixed pulley. It is equally true of every caſe of acting machinery: for if the force at the impelled point be greater than what balances the reſiſtance acting at the ſame point, it muſt accelerate that point, and therefore accelerate the whole machine; and if the impelling force be leſs than this, the machine muſt immediately retard in its motion. When the machine has once acquired this degree of motion, every part of it will continue in its preſent ſtate of motion, if only the two external forces are in equilibrio, but not otherwiſe. But when the preſſure of the external power on the impelled point balances the reſiſtance oppoſed by that point, it is, in fact, maintaining the equilibrium with the external power acting at the working point; for this is the only way that external forces can be ſet in oppoſition to each other by the intervention of a body. The external forces are not in immediate equilibrio with each other, but each is in equilibrio with the force exerted by the point on which it acts. This force exerted by the point is a modification of the connecting forces of the body, all of which are brought into action by means of the actions of the external forces, and each is accompanied by a force preciſely equal and oppoſite to it. Now, the principles of ſtatics teach us the proportions of the external preſſures which are thus ſet in equilibrium by the intervention of a body; and therefore teach us what proportion of power and reſiſtance will keep a machine of a given conſtruction in a ſtate of uniform motion.

This propoſition appears paradoxical, and contrary to common obſervation; for we find, that, in order to make a mill go faſter, we muſt either diminiſh the reſiſtance, or we muſt employ more men, or more water, or water moving with greater velocity, &c. But this ariſes from ſome of the cauſes already mentioned. Either the reſiſtance of the work is greater when the machine is made to move faſter, or the impulſion of the power is diminiſhed, or both theſe changes obtain. Friction and reſiſtance of air alſo come in for their ſhare, &c. The actual preſſure of a given quantity of the external power is diminiſhed, and therefore more of it muſt be employed. When a weight is *uniformly* raiſed by a machine, the preſſure exerted on it by the working point is preciſely equal to its weight, whatever be the velocity with which it riſes. But, even in this ſimpleſt caſe, more natural power muſt be expended in order to raiſe it faſter; becauſe either more natural power muſt be employed to accelerate the external matter which is to preſs forward the impelled point, or the relative motion of the preſſing matter will be diminiſhed.

It is well known, that, in the employment of the mechanic powers, whether in their ſtate of greateſt ſimplicity, or any how combined in a complicated machine, if the machine be put in motion, the velocities of the extreme points (which we have called the *impelled* and *working* points) are inverſely proportional to the forces which are in equilibrio when applied to theſe points in the direction of their motion. This is an inductive propoſition, and has been uſed as the foundation of ſyſtems of mechanics. It is unneceſſary to take up time in proving what is ſo familiarly known; conſequently, the products of the preſſures at theſe points by the velocities of the motions are equal; that is, the product of the preſſure actually exerted at the impelled point of a machine working uniformly, multiplied by the velocity of that point, is equal to the product of the reſiſtance actually exerted at the working point, multiplied by the velocity of that point, that is, by the velocity with which the reſiſtance is overcome,

$$p\,m = r\,n.$$

Now, the product of the reſiſtance, by the velocity with which it is overcome, is evidently the meaſure of the performance of the machine, or the work done. The product of the actual preſſure on the impelled point, by the velocity of that point, may be called the MOMENTUM OF IMPULSE.

Hence we deduce this propoſition:

25
Second principle. Momentum of impulſe and the performance of the machine are equal.

In all working machines which have acquired a uniform motion, the performance of the machine is equal to the momentum of impulſe (A).

(A) The truth of this propoſition has been long perceived in every particular inſtance that happened to engage the attention; but we do not recollect any mechanician before Mr Euler conſidering it as a general truth, expreſſing in a few words a mechanical law. This celebrated mathematician undertook, about the year 1735 or 1736, a general and ſyſtematic view of machines, in order to found a complete theory immediately conducive to the improvement of practical mechanics. In 1743 he publiſhed the firſt propoſitions of this uſeful theory in the 10th volume of the *Comment. Petropolitani*, containing the excellent dynamical theorems of which we have given the ſubſtance. In the 3d volume of the *Comment. Novi Petropol.* he proſecuted the ſubject a little farther; and in the 8th volume, he entered on what we are now engaged in, and formally announces this fundamental propoſition, calling theſe two products the *momentum of impulſe*, and the *momentum of effect*. It is much to be regretted, that this conſummate mathematician did not continue theſe uſeful labours; his ardent mind being carried away by more abſtruſe ſpeculations in all the moſt refined departments of mathematics and philoſophy. No man in Europe could have proſecuted the ſubject with more judgment and ſucceſs.—See alſo *Mem. Acad. Berlin*, 1747 and 1752.

This is a propoſition of the utmoſt importance in the ſcience of machines, and leads to the fundamental maxim of their conſtruction. Since the performance of a machine is equal to the momentum of impulſe, it increaſes and diminiſhes along with it, and is a maximum when the momentum of impuſe is a maximum; therefore, the fundamental maxim in the conſtruction of a machine is to faſhion it in ſuch a manner, that the momentum of impulſe ſhall be a maximum, or that the product of the preſſure actually exerted on the impelled point of the machine by the velocity with which it moves may be as great as poſſible. Then are we certain that the product of the reſiſtance, by the velocity of the working point, is as great as poſſible, provided that we take care that none of the impulſe be needleſsly waſted by the way by injudicious communications of motion, by friction, by unbalanced loads, and by reciprocal motions, which irrecoverably waſte the impelling power. This maxim holds good, whether the reſiſtance remains conſtantly the ſame, or varies by any law whatever.

26 Important deſiderata for practice.

But much remains to be done for the improvement of mechanical ſcience before we can avail ourſelves of this maxim, and apply it with ſucceſs. The chief thing, and to this we ſhould give the moſt unremitting attention, is, to learn the changes which obtain in the actual preſſure exerted by thoſe natural powers which we can command; the changes of actual preſſure produced by a change of the velocity of the impelled point of the machine. Theſe depend on the ſpecific natures of thoſe powers, and are different in almoſt every different caſe. Nothing will more contribute to the improvement of practical mechanics than a ſeries of experiments, well contrived, and accurately made, for diſcovering thoſe laws of variation, in the caſes of thoſe powers which are moſt frequently employed. Such experiments, however, would be coſtly, beyond the abilities of an individual; therefore, it were greatly to be wiſhed that public aid were given to ſome perſons of ſkill in the ſcience to inſtitute a regular train of experiments of this kind. An experimental machine might be conſtructed, to be wrought either by men or by cattle. This ſhould be loaded with ſome kind of work which can be very accurately meaſured, and the load varied at pleaſure. When loaded to a certain degree, the men or cattle ſhould be made to work at the rate which they can continue from day to day. The number of turns made in an hour, multiplied by the load, will give the performance correſponding to the velocities; and thus will be diſcovered the moſt advantageous rate of motion. The ſame machine ſhould alſo be fitted for grinding, for ſawing, boring, &c. and ſimilar experiments will diſcover the relation between the velocities with which theſe operations are performed, and the reſiſtances which they exert. The laws of friction may be inveſtigated by the ſame machine. It ſhould alſo be fitted with a walking wheel, and the trial ſhould be made of the ſlope and the velocity of walking which gives the greateſt momentum of impulſe. It is not unreaſonable to expect great advantages from ſuch a train of experiments.

27 A ſubſtitute for them.

Till this be done, we muſt content ourſelves with eſtabliſhing the above, in the moſt general terms, applicable to any caſe in which the law of the variation of force may hereafter be diſcovered.

There is a certain velocity of the impelled point of a machine which puts an end to the action of the moving power. Thus, if the floats of an underſhot wheel be moving with the velocity of the ſtream, no impulſe is made on them. If the arm of a gin or capſtan be moving with that velocity with which a horſe or a man can juſt move, ſo as to continue at that ſpeed from day to day, employing all his working ſtrength, but not fatiguing himſelf; in this ſtate of motion, the animal can exert no preſſure on the machine. This may be called the EXTINGUISHING VELOCITY, and we may expreſs it by the ſymbol e. Let f be that degree of force or preſſure which the animal can exert at a dead pull or thruſt, as it is called. We do not mean the utmoſt ſtrain of which the animal is capable, but that which it can continue unremittingly during the working hours of a day, fully employing, but not fatiguing itſelf. And let p be the preſſure which it actually exerts on the impelled point of a machine, moving with the velocity m. Let $e-m$ be called the RELATIVE VELOCITY, and let it be expreſſed by v. And let it be ſuppoſed, that it has been diſcovered, by any means whatever, that the actual preſſure varies in the proportion of v^q, or $\overline{e-m}^q$. This ſuppoſition gives us $e^q : v^q = f : p$, and $p = f \times \frac{v^q}{e^q}$. For the machine muſt be at reſt, in order that the agent may be able to exert the force f on its impelled point. But when the machine is at reſt, what we have named the relative velocity is e, the whole of the extinguiſhing velocity.

The momentum of impulſe is $p\,m$, that is $\frac{v^q}{e^q} f\,m$, or $f \times \frac{v^q}{e^q} \times \overline{e-v}$ (becauſe $m = e - v$). Therefore $f \times \frac{v^q}{e^q} \times \overline{e-v}$ muſt be made a maximum. But f and e^q are two quantities which ſuffer no change. Therefore the momentum of impulſe will be a maximum when $v^q \times \overline{e-v}$ is a maximum. Now $v^q \times \overline{e-v} = v^q e - v^q v, = v^q e - v^{q+1}$. The fluxion of this is $q e v^{q-1} \dot{v} - \overline{q+1}\, v^q \dot{v}$. This being ſuppoſed $= 0$, we have the equation

$$q e v^{q-1} = \overline{q+1}\, v^q$$

$$\text{And } q e = \overline{q+1}\, v$$

$$\text{Therefore } v = \frac{q e}{q+1}$$

And m, which is $= e - v$, becomes $\frac{e}{q+1}$. Therefore we muſt order matters ſo, that the velocity of the impelled point of the machine may be $= \frac{e}{q+1}$. Now p is $= f \frac{v^q}{e^q}$, and therefore $= f \times \frac{q^q}{\overline{q+1}^q}$. And $p\,m$, $= f \frac{q^q}{\overline{q+1}^q} m, = f \frac{q^q}{\overline{q+1}^q} \times \frac{e}{q+1}, = f \times \frac{q^q e}{\overline{q+1}^{q+1}}, =$ the momentum of impulſe, and therefore $=$ the momentum of effect, or the performance of the machine, when in its beſt ſtate.

28 Example in underſhot mills by Mr Parent.

Thus may the maxim of conſtruction be ſaid to be brought to a ſtate of great ſimplicity, and of moſt eaſy recollection. A particular caſe of this maxim has been long known, having been pointed out by Mr Parent. Since the action of bodies depends on their relative velocity,

locity, the impulſe of fluids muſt be as the ſquare of the relative velocity. From which Mr Parent deduced, that the moſt advantageous velocity of the floats of an underſhot wheel is one-third of that of the ſtream. This maxim is evidently included in our general propoſition; for in this caſe, the index q of that function of the relative velocity v, which is proportional to the impulſe, is $= 2$. Therefore we have the maximum when $v = \frac{2e}{2+1}, = \frac{2}{3}e$, and $m = \frac{1}{3}e$. e, the extinguiſhing velocity, is evidently the velocity of the ſtream. Our propoſition alſo gives us the preciſe value of the performance. The impulſe of the ſtream on the float at reſt being ſuppoſed $= f$, its impulſe on the float moving with the velocity $\frac{2}{3}e$ muſt be $= \frac{4}{9}f$. This is the meaſure of the actual preſſure p. This being multiplied by m, or by $\frac{1}{3}e$, gives $\frac{4}{27}f$. Now f is conſidered as equal to the weight of a column of water, having the ſurface of the floatboard for its baſe, and the depth of the ſluice under the ſurface of the reſervoir (or, more accurately, the fall required for generating the velocity of the ſtream) for its height. Hence it has been concluded, that the utmoſt performance of an underſhot wheel is to raiſe $\frac{4}{27}$ of the water which impels it, to the height from which it falls. But this is not found very agreeable to obſervation. Friction, and many imperfections of execution in the delivery of the water, the direction of its impulſe, &c. may be expected to make a defalcation from this theoretical performance. But the actual performance, even of mills of acknowledged imperfection, conſiderably exceeds this, and ſometimes is found nearly double of this quantity. The truth is, that the particular fact from which Mr Parent firſt deduced this maxim (namely, the performance of what is called *Parent's* or *Dr Barker's mill*), is, perhaps of all that could have been ſelected, the leaſt calculated for being the foundation of a general rule, being of a nature ſo abſtruſe, that the firſt mathematicians of Europe are to this day doubtful whether they have a juſt conception of its principles. Mr Smeaton's experiments ſhew very diſtinctly, that the maximum of performance of an underſhot wheel correſponds to a velocity conſiderably greater than one-third of the ſtream, and approaches nearly to one-half; and he aſſigns ſome reaſons for this which ſeem well founded. But, independent of this, the performance of Mr Smeaton's model was much greater than what correſponds with the velocity by the above mentioned eſtimation of f. The theory of the impulſion of fluids is extremely imperfect; and Daniel Bernoulli ſhews, from very unqueſtionable principles, that the impulſe of a narrow vein of fluid on an extended ſurface is double of what was generally ſuppoſed; and his concluſions are abundantly confirmed by the experiments adduced by him.

Not accurate.

29
This ſubſtitute is uſeful, even where it is not altogether exact.

It is by no means pretended, that the maxim of conſtruction is reduced to the great ſimplicity enounced in the propoſition now under conſideration. We only ſuppoſed, that a caſe had been obſerved where the preſſure exerted by ſome natural agent did follow the proportions of v^q. This being admitted, the propoſition is ſtrictly true. But we do not know any ſuch caſe; yet is the propoſition of conſiderable uſe: for we can affirm, on the authority of our own obſervations, that the action both of men and of draught horſes does not deviate very far from the proportions of v^2. The obſervations were made on men and horſes tracking a lighter along a canal, and working ſeveral days together, without having any knowledge of the purpoſe of the obſervations. The force exerted was firſt meaſured by the curvature and weight of the track rope, and afterwards by a ſpring ſteelyard. This was multiplied by the number of yards per hour, and the product conſidered as the momentum. We found the action of men to be very nearly as $\overline{e - m}^2$. The action of horſes, loaded ſo as not to be able to trot, was nearly as $\overline{e - m}^{1,7}$.

The practitioner can eaſily avail himſelf of the maxim, although the function q ſhould never be reduced to any algebraic form. He has only to inſtitute a train of experiments on the natural agent, and ſelect that velocity which gives the higheſt product when multiplied by its correſponding preſſure.

30
Two methods of availing ourſelves of this maxim.

When this ſelection has been made, we have two ways of giving our working machines the maximum of effect, having once aſcertained the preſſure f which our natural power exerts on the impelled point of the machine when it is not allowed to move.

1. When the reſiſtance ariſing from the work, and from friction, is a given quantity; as when water is to be raiſed to a certain height by a piſton of given dimenſions.

Since the friction in all the communicating parts of the machine vary in the ſame proportion with the preſſure, and ſince theſe vary in the ſame proportion with the reſiſtance, the ſum of the reſiſtance and friction may be repreſented by $b\,r$, b being an abſtract number. Let n be the undetermined velocity of the working point; or let $m : n$ be the proportion of velocities at the impelled and working points. Then, becauſe the preſſures at theſe points balance each other, in the caſe of uniform motion, they are inverſely as the velocities at thoſe points. Therefore we muſt make $b\,r : p = m : n$, and $n = \frac{p\,m}{b\,r}, = \frac{\frac{q^q}{\overline{q+1}^q} f\,m}{b\,r}, = m \frac{q^q f}{\overline{q+1}^q b\,r}$, or $m : n = \overline{q+1}^q \times b\,r : q^q f$.

2. On the other hand, when $m : n$ is already given, by the conſtruction of the machine, but $b\,r$ is ſuſceptible of variation, we muſt load the machine with more and more work, till we have reduced the velocity of its impelled point to $\frac{e}{q+1}$.

In either caſe, the performance is expreſſed by what expreſſes $p\,m$, that is, by $f\,e \times \frac{q^q}{\overline{q+1}^{q+1}}$. But the uſeful performance, which is really the work done, will be had by dividing the value now obtained by the number b, which expreſſes the ſum of the reſiſtance overcome by the working point and the friction of the machine.

Recapitulation.

What has been now delivered contains, we imagine, the chief principles of the theory of machines, and points out the way in which we muſt proceed in applying them to every caſe. The reader, we hope, ſees clearly the imperfection of a conſideration

tion of machines which proceeds no farther than the ſtatement of the proportions of the ſimultaneous preſſures which are excited in all the parts of the machine by the application of the external forces, which we are accuſtomed to call the *power* and the *weight*. Unleſs we take alſo into conſideration, the immediate effect of mechanical force applied to body, and combine this with all the preſſures which ſtatical principles have enabled us to aſcertain, and by this combination be able to ſay what portion of unbalanced force there is acting at one and all of the preſſing points of the machine, and what will be the motion of *every part* of it in conſequence of this overplus, we have acquired no knowledge that can be of ſervice to us. We have been contemplating, not a working machine, but a ſort of balance. But, by reaſoning about theſe unbalanced forces in the ſame ſimple manner as about the fall of heavy bodies, we were able to diſcover the momentary accelerations of every part, and the ſenſible motion which it would acquire in any aſſigned time, if all the circumſtances remain the ſame. We found that the reſults, although deduced from unqueſtionable principles, were quite unlike the obſerved motions of moſt working machines. Proceeding ſtill on the ſame principles, we conſidered this deviation as the indication, and the preciſe meaſure, of ſomething which we had not yet attended to, but which the deviation brought into view, and enabled us to aſcertain with accuracy. Theſe are the changes which happen in the exertions of our actuating powers by the velocity with which we find it convenient to make them act. Thus we learn more of the nature of thoſe powers; and we found it neceſſary to diſtinguiſh carefully between the apparent magnitude of our actuating power and its real exertion in doing our work. This conſideration led us to a fundamental propoſition concerning all working machines when they have attained an uniform motion; namely, that the power and reſiſtance then really exerted on the machine preciſely balance each other, and that the machine is preciſely in the condition of a ſteelyard loaded with its balanced weights, and moved round its axis by ſome external force diſtinct from the power and the weight. We found that this force is the previous overplus of impelling power, before the machine had acquired the uniform motion; and on this occaſion we learned to eſtimate the effect produced, by the momentum (depending on the form of the machine) of the quantity of motion produced in the whole aſſemblage of power, reſiſtance, and machine.

31 Theory of machines ſtill intricate, eſpecially of ſuch as reciprocate.

The theory of machines ſeemed to be now brought back to that ſimplicity of equilibrium which we had ſaid was ſo imperfect a foundation for a theory; but in the availing ourſelves of the maxim founded on this general propoſition, we ſaw that the equilibrium is of a very different kind from a quieſcent equilibrium. It neceſſarily involves in it the knowledge of the momentary accelerations and their momenta; without which we ſhould not perceive that one ſtate of motion is more advantageous than another, becauſe all give us the ſame proportion of forces in equilibrio.

But this is not the only uſe of the previous knowledge of the momentary accelerations of machines; there are many caſes where the machine works in this very ſtate. Many machines accelerate throughout while performing their work; and their efficacy depends entirely on the final acceleration. Of this kind is the coining preſs, the great forge or tilt mill, and ſome other capital engines. The ſteam engine, and the common pump, are neceſſarily of this claſs, although their efficacy is not eſtimated by their final acceleration. A great number of engines have reciprocating motions in different ſubordinate parts. The theory of all ſuch engines requires for its perfection an accurate knowledge of the momentary accelerations; and we muſt uſe the formulæ contained in the firſt part of this article.

32 Working and returning ſtrokes.

Still, however, the application of this knowledge has many difficulties, which make a *good* theory of ſuch machines a much more intricate and complicated matter than we have yet led the reader to ſuppoſe. In moſt of theſe engines, the whole motion may be divided into two parts. One may be called the WORKING STROKE, and the other in which the working points are brought back to a ſituation which fits them for acting again, may be called the RETURNING STROKE. This return muſt be effected either by means of ſome immediate application of the actuating power, or by ſome other force, which is counteracted during the working ſtroke, and muſt be conſidered as making part of the reſiſtance. In the ſteam engine, it is generally done by a counterpoiſe on the outer end of the great working beam. This muſt be accounted a part of the reſiſtance, for it muſt be raiſed again; and the proportions of the machine for attaining the maximum muſt be computed accordingly. The quantity of this counterpoiſe muſt be adjuſted by other conſiderations. It muſt be ſuch, that the deſcent of the pump rods in the pit may *juſt employ the whole time* that is neceſſary for filling the cylinder with ſteam. If they deſcend more briſkly (which an unſkilful engineer likes to ſee), this muſt be done by means of a greater counterpoiſe, and this employs more power to raiſe it again. Deſaguliers deſcribes a very excellent machine for raiſing water in a bucket by a man's ſtepping into an oppoſite bucket, and deſcending by his preponderancy. When he comes to the bottom, he ſteps out, goes up a ſtair, and finds the bucket returned and ready to receive him again. This machine is extremely ſimple, and perhaps the beſt that can be contrived; and yet it is one of the moſt likely to be a very bad one. The bucket into which the man ſteps muſt be brought up to its place again by a preponderancy in the machine when unloaded. It may be returned ſooner or later. It ſhould arrive preciſely at the ſame time with the man. If ſooner, it is of no uſe, and waſtes power in raiſing a counterpoiſe which is needleſsly heavy; if later, time is loſt: Therefore, the perfection of this very ſimple machine requires the judicious combination of two maximums, each of which varies in a ratio compounded of two other ratios. Suppoſe the man to employ a minute to go up ſtairs 50 feet, which is very nearly what he can do from day to day as his only work, and ſuppoſe him to weigh 150 pounds, and that he acts by means of a ſimple pulley—the maximum for a lever of equal arms would require him to raiſe about 6[illegible] pounds of water. But when all the other circumſtances are calculated, it will be found that he muſt raiſe 138 pounds (neglecting the inertia of the machine). He ſhould raiſe 542 pounds 10 feet in a minute; and this is nearly the moſt exact valuation of a man's work.

There is the ſame neceſſity of attending to a variety of circumſtances in all machines which reciprocate in the whole or any conſiderable part of their motion. The force employed for bringing the machine into another working poſition, muſt be regulated by the time neceſſary for obtaining a new ſupply of power; and then the proportion of *m* to *n* muſt be ſo adjuſted, that the work performed, divided by the *whole* time of the working and returning ſtrokes, may give the greateſt quotient. It is ſtill a difficult thing, therefore, to conſtruct a machine in the moſt perfect manner, or even to ſay what will be the performance of a machine already conſtructed; yet we ſee that every circumſtance is ſuſceptible of accurate computation.

With reſpect to machines which acquire a ſort of uniform motion in general, although ſubject to partial reciprocations, as in a pumping, ſtamping, forging engine, it is alſo difficult to aſſign the rate even of this general uniform motion. We may, however, ſay, that it will not be greater than if it were uniform throughout. Were it entirely free from friction, it would be exactly the ſame as if uniform; becauſe the accelerations during the advantageous ſituations of the impelling power would compenſate the retardations. But friction diminiſhes the accelerations, without diminiſhing the retardations.

We may conclude this article with ſome obſervations tending to the general improvement of machines.

33
Uniformity of motion throughout is of great advantage.

Nothing contributes more to the perfection of a machine, eſpecially ſuch as is maſſive and ponderous, than great uniformity of motion. Every irregularity of motion waſtes ſome of the impelling power; and it is only the greateſt of the varying velocities which is equal to that which the machine would acquire if moving uniformly throughout; for while the motion accelerates, the impelling force is greater than what balances the reſiſtance then actually oppoſed to it, and the velocity is leſs than what the machine would acquire if moving uniformly: and when the machine attains its greateſt velocity, it attains it becauſe the power is then not acting againſt the whole reſiſtance. In both of theſe ſituations, therefore, the performance of the machine is leſs than if the power and reſiſtance were exactly balanced; in which caſe it would move uniformly.

34
How to attain this.

Every attention ſhould therefore be given to this, and we ſhould endeavour to remove all cauſe of irregularity. The communications of motion ſhould be ſo contrived, that if the impelled point be moving uniformly, by the uniform preſſure of the power, the working point ſhall alſo be moving uniformly. Then we may generally be certain, that the maſſy parts of the machine will be moving uniformly. When this is not done through the whole machine, there are continual returns of ſtrains and jolts; the inertia of the different parts acting in oppoſite directions. Although the whole momenta may always balance each other, yet the general motion is hobbling, and the points of ſupport are ſtrained. A great engine ſo conſtructed, commonly cauſes the building to tremble; but when uniform motion pervades the whole machine, the inertia of each part tends to preſerve this uniformity, and all goes ſmoothly. It is alſo deſerving of remark, that when the communications are ſo contrived that the uniform motion of one part produces uniform motion on the next, the preſſures at the communicating points remain conſtant or invariable. Now the accompliſhing of this is always within the reach of mechanics.

35
Beſt forms for the teeth of wheels.
Plate XXXIII. fig. 1.

One of the moſt uſual communications in machinery is by means of toothed wheels acting on each other. It is of importance to have the teeth ſo formed, that the preſſure by which one of them A urges the other B round its axis ſhall be conſtantly the ſame. It can eaſily be demonſtrated, that when this is the caſe, the uniform angular motion of the one will produce a uniform angular motion of the other; or, if the motions are thus uniform, the preſſures are invariable. This is accompliſhed on this principle, that the mutual actions of ſolid bodies on each other in the way of preſſure are perpendicular to the touching ſurfaces. Therefore let the tooth *a* preſs on the tooth *b* in the point C; and draw the line FCDE perpendicular to the touching ſurfaces in the point C. Draw AF, BE perpendicular to FE, and let FE cut the line AB in D. It is plain, from the common principles of mechanics, that if the line FE, drawn in the manner now deſcribed, always paſs through the ſame point D, whatever may be the ſituation of the acting teeth, the mutual action of the wheels will always be the ſame. It will be the ſame as if the arm AD acted on the arm BD. In the treatiſes on the conſtruction of mills, and other works of this kind, are many inſtructions for the formation of the teeth of wheels; and almoſt every noted millwright has his own noſtrums. Moſt of them are egregiouſly faulty in reſpect of mechanical principle. Indeed they are little elſe than inſtructions how to make the teeth clear each other without ſticking. Mr de la Hire firſt pointed out the above mentioned principle, and juſtly condemned the common practice of making the ſmall wheel or pinion in the form of a lantern (whence it alſo took its name), conſiſting of two round diſks, having a number of cylindrical ſpokes (fig. 2.) The ſlighteſt inſpection of this conſtruction ſhews, that, in the different ſituations of the working teeth, the line FCE continually changes its interſection with AB. If the wheel B be very ſmall in compariſon of the other, and if the teeth of A take deep hold of the cylindrical pins of B, the line of action EF is ſometimes ſo diſadvantageouſly placed, that the preſſure of the one wheel has ſcarcely any tendency at all to turn the other. Mr de la Hire, or Dr Hooke, was, we think, the firſt who inveſtigated the form of tooth which procured this conſtant action between the wheels; and in a very ingenious diſſertation, publiſhed among the Memoirs of the Academy of Sciences at Paris 1668, the former of theſe gentlemen ſhews, that this will be enſured by forming the teeth into epicycloids. Mr Camus of the ſame Academy has publiſhed an elaborate diſſertation on the ſame ſubject, in which he proſecutes the principle of Mr de la Hire, and applies it to all the variety of caſes which can occur in practice. There is no doubt as to the goodneſs of the principle; and it has another excellent property, "that the mutual action of the teeth is abſolutely without any friction." The one tooth only applies itſelf to the other, and rolls on it, but does not ſlide or rub in the ſmalleſt degree. This makes them laſt long, or rather does not allow them to wear in the leaſt. But the conſtruction is ſubject to a limitation which muſt not be neglected. The teeth muſt be ſo made, that the curved part of the tooth *b* is acted on by a flat part of the tooth *a* till it comes to the line AB in the courſe of its action; after

Epicycloids recommended by De la Hire.

which the curved part of *a* acts on a flat part of *b*; or the whole action of *a* on *b* is either completed, or only begins at the line AB, joining the centres of the wheels.

36 A better form.

Another form of the teeth ſecures the perfect uniformity of action without this limitation, which requires very nice execution. Let the teeth of each wheel be formed by evolving its circumference; that is, let the acting face GCH of the tooth *a* have the form of the curve traced by the extremity of the thread FC, unlapped from the circumference. In like manner, let the acting face of the tooth *b* be formed by unlapping a thread from its circumference. It is evident, that the line FCE, which is drawn perpendicularly to the touching ſurfaces in the point C, is juſt the direction or poſition of the evolving threads by which the two acting faces are formed. This line muſt therefore be the common tangent to the two circles or circumferences of the wheels, and will therefore always cut the line AB in the ſame point D. This form allows the teeth to act on each other through the whole extent of the line FCE, and therefore will admit of ſeveral teeth to be acting at the ſame time (twice the number that can be admitted in Mr de la Hire's method). This, by dividing the preſſure among ſeveral teeth, diminiſhes its quantity on any one of them, and therefore diminiſhes the dents or impreſſions which they unavoidably make on each other. It is not altogether free from ſliding and friction, but the whole of it can hardly be ſaid to be ſenſible. The whole ſlide of a tooth three inches long, belonging to a wheel of ten feet diameter, acting on a tooth of a wheel of two feet diameter, does not amount to $\frac{1}{80}$th of an inch, a quantity altogether inſignificant.

In the formation of the teeth of wheels, a ſmall deviation from theſe perfect forms is not perhaps of very great importance, except in caſes where a very large wheel drives a very ſmall one (a thing which a good engineer will always avoid). As the conſtruction, however, is exceedingly eaſy, it would he unpardonable to omit it. Well formed teeth, and a great number of them acting at once, make the communication of motion extremely ſmooth and uniform. The machine works without noiſe, and the teeth laſt a very long time without ſenſibly changing their ſhape. But there are caſes, ſuch as the pallets of clocks and watches, where the utmoſt accuracy of form is of the greateſt importance for the perfection of the work.

37 Maxim for the conſtruction of ſtampers, &c.

When heavy ſtampers are to be raiſed, in order to drop on the matters to be pounded, the wipers by which they are lifted ſhould be made of ſuch a form, that the ſtamper may be raiſed by a uniform preſſure, or with a motion almoſt perfectly uniform. If this is not attended to, and the wiper is only a pin ſticking out from the axis, the ſtamper is forced into motion at once. This occaſions violent jolts to the machine, and great ſtrains on its moving parts and their points of ſupport; whereas when they are gradually lifted, the inequality of deſultory motion is never felt at the impelled point of the machine. We have ſeen piſtons moved by means of a double rack on the piſton-rod. A half wheel takes hold of one rack, and raiſes it to the required height. The moment the half wheel has quitted that ſide of the rack, it lays hold of the other ſide, and forces the piſton down again. This is propoſed as a great improvement; correcting the unequable motion of the piſton moved in the common way by a crank. But it is far inferior to the crank motion. It occaſions ſuch abrupt changes of motion, that the machine is ſhaken by jolts. Indeed if the movement were accurately executed, the machine would be ſhaken to pieces, if the parts did not give way by bending and yielding. Accordingly, we have always obſerved that this motion ſoon failed, and was changed for one that was more ſmooth. A judicious engineer will avoid all ſuch ſudden changes of motion, eſpecially in any ponderous part of a machine.

When ſeveral ſtampers, piſtons, or other reciprocal movers, are to be raiſed and depreſſed, common ſenſe teaches us to diſtribute their times of action in a uniform manner, ſo that the machine may always be equally loaded with work. When this is done, and the obſervations in the preceding paragraph attended to, the machine may be made to move almoſt as ſmoothly as if there were no reciprocations in it. Nothing ſhews the ingenuity of the author more than the artful yet ſimple and effectual contrivances for obviating thoſe difficulties that unavoidably ariſe from the very nature of the work that muſt be performed by the machine, and of the power employed. The inventive genius and ſound judgment of Watt and Boulton are as perceptible to a ſkilled obſerver in theſe ſubordinate parts of ſome of their great engines, as in the original diſcovery on which their patent is founded. In ſome of thoſe engines the maſs of dead matter which muſt be put into motion, and this motion deſtroyed and again reſtored in every ſtroke, is enormous, amounting to above an hundred tons. The ingenious authors have even contrived to draw ſome advantages from it, by allowing a great want of equilibrium in certain poſitions; and this has been condemned as a blunder by engineers who did not ſee the uſe made of it.

38 The unavoidable inequalities of moving power muſt be compenſated by the conſtruction.

There is alſo great room for ingenuity and good choice in the management of the moving power, when it is ſuch as cannot immediately produce the kind of motion required for effecting the purpoſe. We mentioned the converſion of the continued rotation of an axis into the reciprocating motion of a piſton, and the improvement which was thought to have been made on the common and obvious contrivance of a crank, by ſubſtituting a double rack on the piſton-rod, and the inconvenience ariſing from the jolts occaſioned by this change. We have ſeen a great forge, where the engineer, in order to avoid the ſame inconvenience ariſing from the abrupt motion given to the great ſledge hammer of ſeven hundred weight, reſiſting with a five-fold momentum. formed the wipers into ſpirals, which communicated motion to the hammer almoſt without any jolt whatever; but the reſult was, that the hammer roſe no higher than it had been raiſed in contact with the wiper, and then fell on the iron bloom with very little effect. The cauſe of its inefficiency was not gueſſed at; but it was removed, and wipers of the common form were put in place of the ſpirals. In this operation, the rapid motion of the hammer is abſolutely neceſſary. It is not enough to *lift* it up; it muſt be *toſſed* up, ſo as to fly higher than the wiper lifts it, and to ſtrike with great force the ſtrong oaken ſpring which is placed in its way. It compreſſes this ſpring, and is reflected by it with a conſiderable velocity, ſo as to hit the iron as if it had fallen from a great height. Had it been allowed to fly to that height, it would have fallen upon the iron with ſomewhat more force (becauſe no oaken ſpring is perfectly elaſtic); but this would have required more than twice the time.

38 Great inconveniences of a reciprocating power.

In employing a power which of neceſſity reciprocates, to drive machinery which requires a continuous motion (as in applying the ſteam engine to a cotton or a griſt mill), there alſo occur great difficulties. The neceſſity of reciprocation in the firſt mover waſtes much power; becauſe the inſtrument which communicates ſuch an enormous force muſt be extremely ſtrong, and be well ſupported. The impelling power is waſted in imparting, and afterwards deſtroying, a vaſt quantity of motion in the working beam. The ſkilful engineer will attend to this, and do his utmoſt to procure the neceſſary ſtrength of this firſt mover, without making it a vaſt load of inert matter. He will alſo remark, that all the ſtrains on it, and on its ſupports, are changing their directions in every ſtroke. This requires particular attention to the manner of ſupporting it. If we obſerve the ſteam engines which have been long erected, we ſee that they have uniformly ſhaken the building to pieces. This has been owing to the ignorance or inattention of the engineer in this particular. They are much more judiciouſly erected now, experience having taught the moſt ignorant that no building can withſtand their deſultory and oppoſite jolts, and that the great movements muſt be ſupported by a framework independent of the building of maſonry which contains it (b).

The engineer will alſo remark, that when a ſingle ſtroke ſteam engine is made to turn a mill, all the communications of motion change the direction of their preſſure twice every ſtroke. During the working ſtroke of the beam, one ſide of the teeth of the intervening wheels is preſſing the machinery forward; but during the returning ſtroke, the machinery, already in motion, is dragging the beam, and the wheels are acting with the other ſide of the teeth. This occaſions a rattling at every change, and makes it proper to faſhion both ſides of the teeth with the ſame care.

It will frequently conduce to the good performance of an engine, to make the action of the reſiſting work unequable, accommodated to the inequalities of the impelling power. This will produce a more uniform motion in machines in which the momentum of inertia is inconſiderable. There are ſome beautiful ſpecimens of this kind of adjuſtment in the mechaniſm of animal bodies.

39 Nature, operation, and uſe of a Fly.

It is very cuſtomary to add what is called a Fly to machines. This is a heavy diſk or hoop, or other maſs of matter, *balanced on its axis*, and ſo connected with the machinery as to turn briſkly round with it. This may be done with the view of rendering the motion of the whole more regular, notwithſtanding unavoidable inequalities of the accelerating forces, or of the reſiſtances occaſioned by the work. It becomes a Regulator. Suppoſe the reſiſtance extremely unequal, and the impelling power perfectly conſtant; as when a bucket wheel is employed to work *one* pump. When the piſton has ended its working ſtroke, and while it is going down the barrel, the power of the wheel being ſcarcely oppoſed, it accelerates the whole machine, and the piſton arrives at the bottom of the barrel with a conſiderable velocity. But in the riſing again, the wheel is oppoſed by the column of water now preſſing on the piſton. This immediately retards the wheel; and when the piſton has reached the top of the barrel, all the acceleration is undone, and is to begin again. The motion of ſuch a machine is very hobbling: but the ſuperplus of accelerating force at the beginning of a returning ſtroke will not make ſuch a change in the motion of the machine if we connect the fly with it. For the accelerating momentum is a determinate quantity. Therefore, if the radius of the fly be great, this momentum will be attained by communicating a ſmall angular motion to the machine. The momentum of the fly is as the ſquare of its radius; therefore it reſiſts acceleration in this proportion; and although the overplus of power generates the ſame momentum of rotation in the whole machine as before, it makes but a ſmall addition to its velocity. If the diameter of the fly be doubled, the augmentation of rotation will be reduced to one-fourth. Thus, by giving a rapid motion to a ſmall quantity of matter, the great acceleration during the returning ſtroke of the piſton is prevented. This acceleration continues, however, during the whole of the returning ſtroke, and at the end of it the machine has acquired its greateſt velocity. Now the working ſtroke begins, and the overplus of power is at an end. The machine accelerates no more; but if the power is juſt in equilibrio with the reſiſtance, it keeps the velocity which it has acquired, and is ſtill more accelerated during the *next* returning ſtroke. But now, at the beginning of the ſubſequent working ſtroke, there is an overplus of reſiſtance, and a retardation begins, and continues during the whole riſe of the piſton; but it is inconſiderable in compariſon of what it would have been without the fly; for the fly, retaining its acquired momentum, drags forward the reſt of the machine, aiding the impelling power of the wheel. It does this by all the communications taking into each other in the oppoſite direction. The teeth of the intervening wheels are heard to drop from their former contact on one ſide, to a contact on the other. By conſidering this proceſs with attention, we eaſily perceive that, in a few ſtrokes, the overplus of power during the returning ſtroke comes to be ſo adjuſted to the deficiency during the working ſtroke, that the accelerations and retardations exactly deſtroy each other, and every ſucceeding ſtroke is made with the ſame velocity, and an equal number of ſtrokes is made in every ſucceeding minute. Thus the machine acquires a general uniformity with periodical inequalities. It is plain, that by ſufficiently enlarging either the diameter or the weight of the fly, the irregularity of the motion may be rendered as ſmall as we pleaſe. It is much better to enlarge the diameter. This preſerves the friction more moderate, and the pivot wears leſs. For theſe reaſons, a fly is in general a conſiderable improvement in machinery, by equaliſing many exertions that are naturally very irregular. Thus, a man working at a common windlaſs, exerts a very irregular preſſure on the winch. In one of his poſitions in each turn he can exert a force of near 70 pounds without fatigue, but in another he cannot exert above 25; nor muſt he be loaded with much above this in general. But if a large fly be connected properly with the windlaſs, he will act with equal eaſe and ſpeed againſt 30 pounds.

(b) The gudgeons of a water-wheel ſhould never reſt on the wall of the building. It ſhakes it; and if ſet up ſoon after the building has been erected, it prevents the mortar from taking firm bond; perhaps by ſhattering the calcareous cryſtals as they form. When the engineer is obliged to reſt the gudgeons in this way, they ſhould be ſupported by a block of oak laid a little hollow. This ſoftens all tremors, like the ſprings of a wheel carriage. This practice would be very ſerviceable in many other parts of the conſtruction.

40 It is a powerful regulator.

This regulating power of the fly is without bounds, and may be uſed to render uniform a motion produced by the moſt deſultory and irregular power. It is thus that the moſt regular motion is given to mills that are driven by a ſingle ſtroke ſteam engine, where for two or even three ſeconds there is no force preſſing round the mill. The communication is made through a maſſive fly of very great diameter, whirling with great rapidity. As ſoon as the impulſe ceaſes, the fly, continuing its motion, urges round the whole machinery with almoſt unabated ſpeed. At this inſtant all the teeth, and all the joints, between the fly and the firſt mover, are heard to catch in the oppoſite direction.

If any permanent change ſhould happen in the impelling power, or in the reſiſtance, the fly makes no obſtacle to its producing its full effect on the machine; and it will be obſerved to accelerate or retard uniformly, till a new general ſpeed is acquired exactly correſponding with this new power and reſiſtance.

Many machines include in their conſtruction movements which are equivalent with this intentional regulator. A flour mill, for example, cannot be better regulated than by its milſtone; but in the Albion mills, a heavy fly was added with great propriety; for if the mills had been regulated by their milſtones only, then at every change of ſtroke in the ſteam engine, the whole train of communications between the beam, which is the firſt mover, and the regulating milſtone, which is the very laſt mover, would take in the oppoſite direction. Although each drop in the teeth and joints be but a trifle, the whole, added together, would make a conſiderable jolt. This is avoided by a regulator immediately adjoining to the beam. This continually preſſes the working machinery in one direction. So judiciouſly were the movements of that noble machine contrived, and ſo nicely were they executed, that not the leaſt noiſe was heard, nor the ſlighteſt tremor felt in the building.

Mr Valoué's beautiful pile engine employed at Weſtminſter Bridge is another remarkable inſtance of the regulating power of a fly*. When the ram is dropped, and its follower diſengaged immediately after it, the horſes would inſtantly tumble down, becauſe the load, againſt which they had been ſtraining hard, is at once taken off; but the gin is connected with a very large fly, which checks any remarkable acceleration, allowing the horſes to lean on it during the deſcent of the load; after which their draught recommences immediately. The ſpindles, cards, and bobbins, of a cotton mill, are alſo a ſort of flies. Indeed all bulky machines of the rotative kind tend to preſerve their motion with ſome degree of ſteadineſs, and their great momentum of inertia is as uſeful in this reſpect as it is prejudicial to the acceleration or any reciprocation when wanted.

41 A bad conſtruction of a fly.

There is another kind of regulating fly, conſiſting of wings whirled briſkly round till the reſiſtance of the air prevents any great acceleration. This is a very bad one for a *working* machine, for it produces its effect by *really waſting* a part of the moving power. Frequently it employs a very great and unknown part of it, and robs the proprietor of much work. It ſhould never be introduced into any machine employed in manufactures.

42 A conical pendulum is the moſt perfect regulator.

Some rare caſes occur where a very different regulator is required; where a certain determined velocity is found neceſſary. In this caſe the machine is furniſhed, at its extreme mover, with a conical pendulum, conſiſting of two heavy balls hanging by rods, which move in very nice and ſteady joints at the top of a vertical axis. It is well known, that when this axis turns round, with an angular velocity ſuited to the length of thoſe pendulums, the time of a revolution is determined. Thus, if the length of each pendulum be $39\frac{1}{7}$ inches, the axis will make a revolution in two ſeconds very nearly. If we attempt to force it more ſwiftly round, the balls will recede a little from the axis, but it employs as long time for a revolution as before; and we cannot make it turn ſwifter, unleſs the impelling power be increaſed beyond all probability; in which caſe the pendulum will fly out from the centre till the rods are horizontal, after which every increaſe of power will accelerate the machine very ſenſibly. Watt and Boulton have applied this contrivance with great ingenuity to their ſteam engines, when they are employed for driving machinery for manufactures which have a very changeable reſiſtance, and where a certain ſpeed cannot be much departed from without great inconvenience. They have connected this receſs of the balls from the axis (which gives immediate indication of an increaſe of power or a diminution of reſiſtance) with the cock which admits the ſteam to the working cylinder. The balls flying out, cauſe the cock to cloſe a little, and diminiſh the ſupply of ſteam. The impelling power diminiſhes the next moment, and the balls again approach the axis, and the rotation goes on as before, although there may have occurred a very great exceſs or deficiency of power. The ſame contrivance may be employed to raiſe or lower the feeding ſluice of a water mill employed to drive machinery.

43 A fly ſometimes collects power.

A fly is ſometimes employed for a very different purpoſe from that of a regulator of motion—it is employed as a *collector of power*. Suppoſe all reſiſtance removed from the working point of a machine furniſhed with a very large or heavy fly immediately connected with the working point. When a ſmall force is applied to the impelled point of this machine, motion will begin in the machine, and the fly begin to turn. Continue to preſs uniformly, and the machine will accelerate. This may be continued till the fly has acquired a very rapid motion. If at this moment a reſiſting body be applied to the working point, it will be acted on with very great force; for the fly has now accumulated in its circumference a very great momentum. If a body were expoſed immediately to the action of this circumference, it would be violently ſtruck. Much more will it be ſo, if the body be expoſed to the action of the working point, which perhaps makes one turn while the fly makes a hundred. It will exert a hundred times more force there (very nearly) than at its own circumference. All the motion which has been accumulated on the fly during the whole progreſs of its acceleration is exerted in an inſtant at the working point, multiplied by the momentum depending on the proportion of the parts of the machine. It is thus that the coining preſs performs its office; nay, it is thus that the blackſmith forges a bar of iron. Swinging the great ſledge hammer round his head, and urging it with force the whole way. this accumulated motion is at once extinguiſhed by impact on the iron. It is thus we drive a nail; and it is thus that by accumulating a very moderate force exerted during four or five turns of a fly, the whole of it is exerted on a punch ſet on a thick plate of iron, ſuch as is employed for the boilers of ſteam engines. The plate is pierced as if it were a bit of cheeſe. This accumulating power of a fly has occaſioned many who think themſelves engineers to imagine, that a fly really adds power or mechanical force to an engine; and, not underſtanding on what its efficacy depends, they often place the fly in a ſituation where it only added a uſeleſs burden to the machine. It ſhould always be made to move with rapidity. If intended for a mere regulator, it ſhould be near the firſt mover. If it is intended to accumulate force in the working point, it ſhould not be far ſeparated from it. In a certain ſenſe, a fly may be ſaid to add power to a machine, becauſe by accumulating into the exertion of one moment the exertions of many, we can ſometimes overcome an obſtacle that we never could have balanced by the ſame machine unaided by the fly.

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* See Pile-*Engine*, Encycl.

It is this accumulation of force which gives ſuch an appearance of power to ſome of our firſt movers. When a man is unfortunately catched by the teeth of a paltry country mill, he is cruſhed almoſt to mummy. The power of the ſtream is conceived to be prodigious; and yet we are certain, upon examination, that it amounts to the preſſure of no more than fifty or ſixty pounds. But it has been acting for ſome time; and there is a milſtone of a ton weight whirling twice round in a ſecond. This is the force that cruſhed the unfortunate man; and it required it all to do it, for the mill ſtopped: We ſaw a mill in the neighbourhood of Elbingroda in Hanover, where there was a contrivance which diſengaged the milſtone when any thing got entangled in the teeth of the wheels. It was tried in our ſight with a head of cabbage. It cruſhed it indeed, but not violently, and would by no means have broken a man's arm.

44 Simplicity of conſtruction recommended.

It is hardly neceſſary to recommend ſimplicity in the conſtruction of machines. This ſeems now ſufficiently underſtood. Multiplicity of motions and communications increaſes frictions; increaſes the unavoidable loſſes by bending and yielding in every part; expoſes to all the imperfections of workmanſhip; and has a great chance of being indiſtinctly conceived, and therefore conſtructed without ſcience. We think the following conſtruction of a capſtan or crab a very good example of the advantages of ſimplicity. It is the invention of an untaught but very ingenious country tradeſman.

45 Example of a very ſimple and powerful capſtan.

Fig. 3. EAB is the barrel of the capſtan, ſtanding vertically in a proper frame, as uſual, and urged round by bars ſuch as EF. The upper part A of the barrel is 17 inches in diameter, and the lower B is 16. C is a ſtrong pulley 16 inches in diameter, having a hook D, which takes hold of a hawſer attached to the load. The rope ACB is wound round the barrel A, paſſes over the pulley C, and is then wound round the barrel B in the oppoſite direction. No farther deſcription is neceſſary, we think, to ſhew that, by heaving by the bar F, ſo as to wind more of the rope upon A, and unwind it from B, the pulley C muſt be brought nearer to the capſtan by about three inches for each turn of the capſtan; and that this ſimple capſtan is equivalent to an ordinary capſtan of the ſame length of bar EF, and diameter of barrel B, combined with a 16 fold tackle of pulleys; or, in ſhort, that it is 16 times more powerful than the common capſtan; free from the great loſs by friction and bending of ropes, which would abſorb a third of the power of a 16 fold tackle; and that whereas all other engines become weaker as they multiply the power to a greater degree (unleſs they are proportionally more bulky), this engine becomes really ſtronger in itſelf. Suppoſe we wanted to have it twice as powerful as at preſent; nothing is neceſſary but to cover the part B of the barrel with laths a quarter of an inch thick. In ſhort, the nearer the two barrels are to equality, the more powerful does it become. We give it to the public as an excellent capſtan, and as ſuggeſting thoughts which an intelligent engineer may employ with great effect. By this contrivance, and uſing an iron wire inſtead of a catgut, we converted a common eight day clock into one which goes for two months.

We intended to conclude this article with ſome obſervations on the chief claſſes of powers which are employed to drive machinery; ſuch as water, wind, atmoſpheric preſſure, gunpowder, and the force of men and other animals, giving ſome notion of their abſolute magnitudes, and the effect which may be expected from them. We ſhould then have mentioned what has been diſcovered as to their variation by a variation of velocity. And we intended to conclude with an account of what knowledge has been acquired concerning friction, and the loſs of power in machinery ariſing from this cauſe, and from the ſtiffneſs of ropes, and ſome other cauſes: But we have not yet been able to bring theſe matters into a connected form, which would ſuggeſt the methods and means of farther information thereon. We muſt endeavour to find another opportunity of communicating to the public what we may yet learn on thoſe ſubjects.

We have now eſtabliſhed the principles on which machines muſt be conſtructed, in order that they may produce the greateſt effect; but it would be improper to diſmiſs the ſubject without ſtating to our readers Mr Bramah's new method of producing and applying a more conſiderable degree of power to all kinds of machinery requiring motion and force, than by any means at preſent practiſed for that purpoſe. This method, for which on the 31ſt of March 1796 he obtained a patent, conſiſts in the application of water or other denſe fluids to various engines, ſo as, in ſome inſtances, to cauſe them to act with immenſe force; in others, to communicate the motion and powers of one part of a machine to ſome other part of the ſame machine; and, laſtly, to communicate the motion and force of one machine to another, where their local ſituations preclude the application of all other methods of connection.

The firſt and moſt material part of this invention will be clearly underſtood by an inſpection of fig. 4. where "A is a cylinder of iron, or other materials, ſufficiently ſtrong, and bored perfectly ſmooth and cylindrical; into which is fitted the piſton B, which muſt be made perfectly water-tight, by leather or other materials, as uſed in pump-making. The bottom of the cylinder muſt alſo be made ſufficiently ſtrong with the other part of the ſurface, to be capable of reſiſting the greateſt force or ſtrain that may at any time be required. In the bottom of the cylinder is inſerted the end of the tube C; the aperture of which communicates with the inſide of the cylinder, under the piſton B, where it is ſhut with the ſmall valve D, the ſame as the ſuction-pipe of a common pump. The other end of the tube C communicates with the ſmall forcing pump or injector E, by means of which water or other denſe fluids can be forced or injected into the cylinder A, under the piſton B. Now, ſuppoſe the diameter of the cylinder A to be 12 inches, and the diameter of the piſton of the ſmall pump or injector E only one quarter of an inch, the proportion between the two ſurfaces or ends of the ſaid piſtons will be as 1 to 2304; and ſuppoſing the intermediate ſpace between them to be filled with water or other denſe fluid capable of ſufficient reſiſtance, the force of one piſton will act on the other juſt in the above proportion, viz. as 1 is to 2304. Suppoſe the ſmall piſton in the injector to be forced down when in the act of pumping or injecting water into the cylinder A, with the power of 20 cwt. which could eaſily be done by the lever H; the piſton B would then be moved up with a force equal to 20 cwt. multiplied by 2304. Thus is conſtructed a hydro-mechanical engine, whereby a weight amounting to 2304 tons can be raiſed by a ſimple lever, through equal ſpace, in much leſs time than could be done by any apparatus conſtructed on the known principles of mechanics; and it may be proper to obſerve, that the effect of all other mechanical combinations is counteracted by an accumulated complication of parts, which renders them incapable of being uſefully extended beyond a certain degree; but in machines acted upon or conſtructed on this principle, every difficulty of this kind is obviated, and their power ſubject to no finite reſtraint. To prove this, it will be only neceſſary to remark, that the force of any machine acting upon this principle can be increaſed *ad infinitum*, either by extending the proportion between the diameter of the injector and the cylinder A, or by applying greater power to the lever H.

"Fig. 5. repreſents the ſection of an engine, by which very wonderful effects may be produced inſtantaneouſly by means of compreſſed air. AA is a cylinder, with the piſton B fitting air-tight, in the ſame manner as deſcribed in fig. 4. C is a globular veſſel made of copper, iron, or other ſtrong materials, capable of reſiſting immenſe force, ſimilar to thoſe of air guns. D is a ſtrong tube of ſmall bore, in which is the ſtop-cock E. One of the ends of this tube communicates with the cylinder under the piſton B, and the other with the globe C. Now, ſuppoſe the cylinder A to be the ſame diameter as that in fig. 4. and the tube D equal to one quarter of an inch diameter, which is the ſame as the injector fig. 4.: then, ſuppoſe that air is injected into the globe C (by the common method), till it preſſes againſt the cock E with a force equal to 20 cwt. which can eaſily be done; the conſequence will be, that when the cock E is opened, the piſton B will be moved in the cylinder AA with a power or force equal to 2304 tons; and it is obvious, as in the caſe fig. 4. that any other unlimited degree of force may be acquired by machines or engines thus conſtructed.

"Fig. 6. is a ſection, merely to ſhew how the power and motion of one machine may, by means of fluids, be transferred or communicated to another, let their diſtance and local ſituation be what they may. A and B are two ſmall cylinders, ſmooth and cylindrical; in the inſide of each of which is a piſton, made water and air tight, as in figs 4. and 5. CC is a tube conveyed under ground, or otherwiſe, from the bottom of one cylinder to the other, to form a communication between them, notwithſtanding their diſtance be ever ſo great; this tube being filled with water or other fluid, until it touch the bottom of each piſton; then, by depreſſing the piſton A, the piſton B will be raiſed. The ſame effect will be produced *vice verſa*: thus bells may be rung, wheels turned, or other machinery put inviſibly in motion, by a power being applied to either.

"Fig. 7. is a ſection, ſhewing another inſtance of communicating the action and force of one machine to another; and how water may be raiſed out of wells of any depth, and at any diſtance from the place where the operating power is applied. A is a cylinder of any required dimenſions, in which is the working piſton B, as in the foregoing examples: into the bottom of this cylinder is inſerted the tube C, which may be of leſs bore than the cylinder A. This tube is continued, in any required direction, down to the pump cylinder D, ſuppoſed to be fixed in the deep well EE, and forms a junction therewith above the piſton F; which piſton has a rod G, working through the ſtuffing-box, as is uſual in a common pump. To this rod G is connected, over a pulley or otherwiſe, a weight H, ſufficient to overbalance the weight of the water in the tube C, and to raiſe the piſton F when the piſton B is lifted: thus, ſuppoſe the piſton B is drawn up by its rod, there will be a vacuum made in the pump cylinder D, below the piſton F; this vacuum will be filled with water through the ſuction pipe, by the preſſure of the atmoſphere, as in all pumps fixed in air. The return of the piſton B, by being preſſed downwards in the cylinder A, will make a ſtroke of the piſton in the pump cylinder D, which may be repeated in the uſual way by the motion of the piſton B, and the action of the water in the tube C. The rod G of the piſton F, and the weight H, are not neceſſary in wells of a depth where the atmoſphere will overbalance the water in the ſuction of the pump cylinder D, and that in the tube C. The ſmall tube and cock in the ciſtern I, are for the purpoſe of charging the tube C."

That theſe contrivances are ingenious, and may occaſionally prove uſeful, we are not inclined to controvert; but we muſt confeſs, that the advantages of them

LABORATORY. PLATE XXXIII.

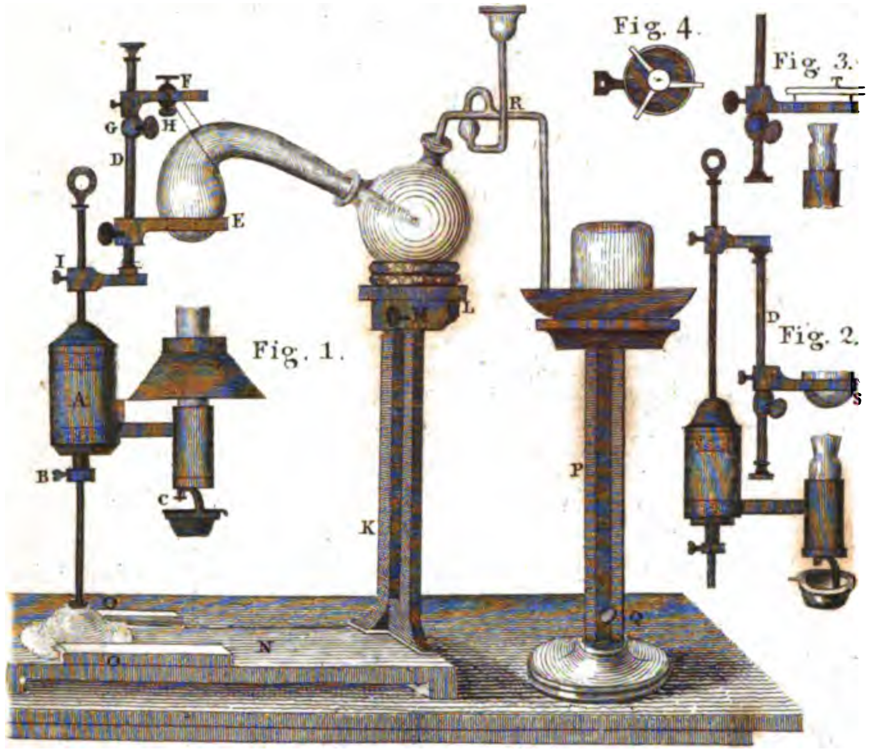


Fig. 2.

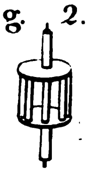


Fig. 1.

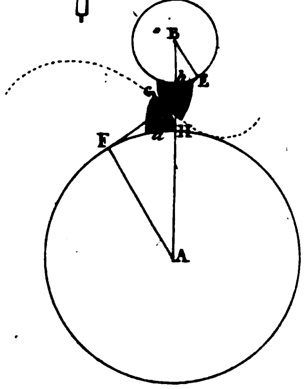


Fig. 3.

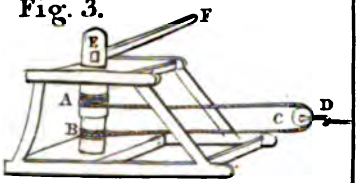
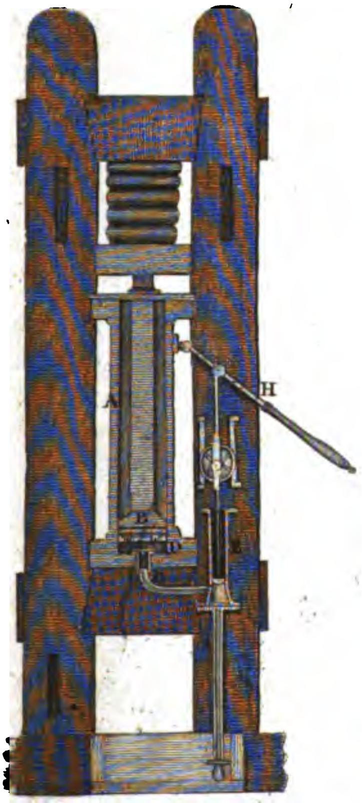
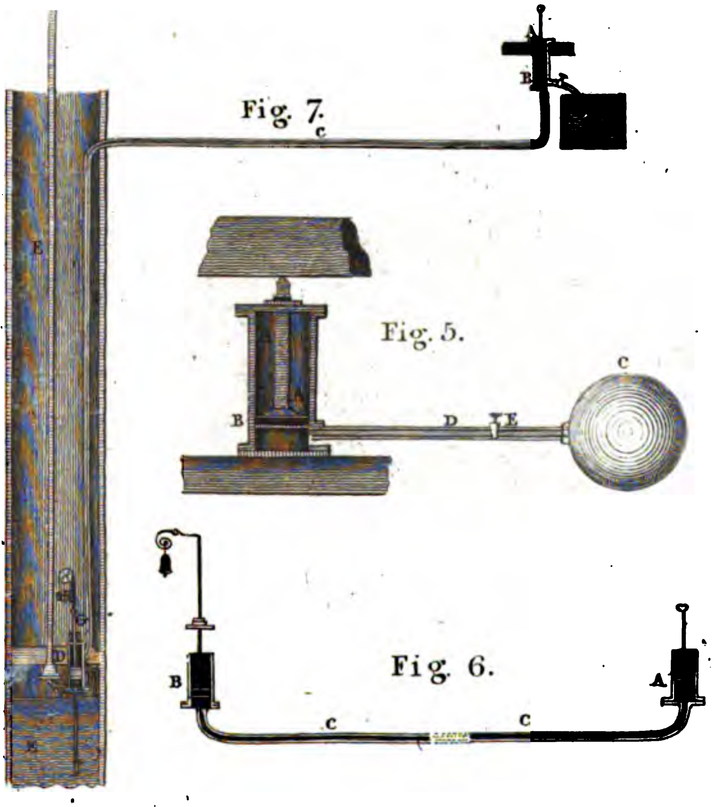


Fig. 4.



MACHINERY



D. Lizars Sculp.

appear not to us ſo great as to their author. Why they do not, we need not explain to any man who, with a ſufficient degree of mechanical and mathematical knowledge, has peruſed this article with attention. *Mr John Luccock*, however, of Marley, near Leeds, thinks ſo very differently from us on this ſubject, that, on Mr Bramah's principle, he propoſes to apply water or other denſe fluids, ſo as to make them ſupply the place of ſteam in what is commonly called the *ſteam engine*. He calls his engine the *paradoxical machine*; and he got a patent for it on the 28th of February 1799, though it differs in nothing from Mr Bramah's machine, repreſented by fig. 4. except that the tube C in the paradoxical machine is ſupplied with water, not by means of a forcing pump, but from a ciſtern elevated to ſuch a height as, that the water deſcending through the tube may produce its effect merely by its weight. Whether this variation, for it is no improvement, of Mr Bramah's machine intitled its author to a patent, it is not our buſineſs to inquire.

Macpherſon.

MACPHERSON (James, Eſq;), was born in the pariſh of Kinguſie, and county of Inverneſs, in the year 1738. His father was a farmer of no great affluence; and young Macpherſon received the earlier part of his education in one of the pariſh ſchools in the diſtrict called Badenoch. By an anonymous writer in the Edinburgh Magazine, he is ſaid to have been educated in the grammar ſchool of Inverneſs; and he may, for ought that we know to the contrary, have ſpent a year in that ſeminary; but we rather think that he went directly from a country ſchool to the univerſity of Aberdeen. At this our readers need not be ſurpriſed; for at the period to which we refer, ſome of the parochial ſchoolmaſters in Scotland, and more eſpecially in the Highlands, were men eminent for taſte and claſſical literature.

It was in the end of October or the 1ſt of November 1752, that James Macpherſon entered the King's College; where he diſplayed more genius than learning, entertaining the ſociety of which he was a member, and even diverting the younger part of it from their ſtudies, by his humorous and doggerel rhimes. About two years after his admiſſion into the univerſity, the King's College added two months to the length of its annual *ſeſſion* or *term;* which induced Macpherſon, with many other young men, to remove to the Mariſchal College, where the ſeſſion continued ſhort; and it is this circumſtance which leads us to ſuppoſe that his father was not opulent.

Soon after he left college, and perhaps before he left it, he was ſchoolmaſter of Ruthven, or Riven, of Badenoch; and we believe he afterwards delighted as little as his great antagoniſt Johnſon in the recollection of that period when he was compelled, by the narrowneſs of his fortune, to teach boys in an obſcure ſchool. It was during this period, we think in 1758, that he publiſhed *The Highlander*, an heroic poem in ſix cantos, 12mo. Of this work, as we have never ſeen it, we can ſay nothing. By the anonymous writer already quoted, it is mentioned as a "tiſſue of fuſtian and abſurdity;" whilſt others, and they too men of learning and character, have aſſured us, that it indicated conſiderable genius in ſo young an author.

Soon after this publication, Mr Macpherſon quitted his ſchool, and was received by Mr Graham of Balgowan into his family as tutor to his ſons; an employment of which he was not fond, and to which he was not long condemned. In the year 1760 he ſurpriſed the world by the publication of *Fragments of Ancient Poetry, collected in the Highlands of Scotland, and Tranſlated from the Gaelic or Erſe Language*, 8vo. Theſe fragments, which were declared to be genuine remains of ancient Scottiſh poetry, at their firſt appearance delighted every reader; and ſome very good judges, and amongſt the reſt Mr Gray, were extremely warm in their praiſes. Macpherſon had intended to bury them in a Scotch magazine, but was prevented from ſo injudicious a ſtep by the advice of a friend. He publiſhed them therefore in a pamphlet by themſelves, and thus laid the foundation of his future fortune.

As other ſpecimens were ſaid to be recoverable, a ſubſcription was ſet on foot by the Faculty of Advocates at Edinburgh, to enable our author to quit the family of Balgowan, perambulate the Highlands, and ſecure, if he could, the precious treaſure. He engaged in the undertaking, and was ſucceſsful; for all who poſſeſſed any of the long famed works, vied with each other in giving or ſending them to a man who had ſhewn himſelf ſo capable of doing them juſtice.

With his collection of poems, and fragments of poems, he went to London; and tagging them together in the form which he thought beſt, he publiſhed, in 1762, *Fingal, an Ancient Epic Poem, in ſix books*, together with ſeveral other poems, compoſed by Oſſian the ſon of Fingal, tranſlated from the Gaelic language, 4to. The ſubject of this epic poem is an invaſion of Ireland by Swaran king of Lochlin. Cuchullin, general of the Iriſh tribes during the minority of Cormac king of Ireland, upon intelligence of the invaſion, aſſembled his forces near Tura, a caſtle on the coaſt of Ulſter. The poem opens with the landing of Swaran; councils are held, battles fought, and Cuchullin is at laſt totally defeated. In the mean time, Fingal, king of the Highlands of Scotland, whoſe aid had been ſolicited before the enemy landed, arrived, and expelled them from the country. This war, which continued but ſix days and as many nights, is, including the epiſodes, the ſtory of the Poem. The ſcene, the heath of Lena, near a mountain called Cromleach in Ulſter. This poem alſo was received with equal applauſe as the preceding Fragments.

The next year he produced *Temora*, an ancient epic poem, in eight books; together with ſeveral other poems compoſed by Oſſian ſon of Fingal, 4to, which, though well received, found the public ſomewhat leſs diſpoſed to beſtow the ſame meaſure of applauſe. Tho' theſe poems had been examined by Dr Blair and others, and their authenticity aſſerted, there were not wanting ſome of equal reputation for critical abilities, who either doubted or declared their diſbelief of the genuineneſs of them. Into this queſtion it would be ſuperfluous to enter here particularly, as we have ſaid enough on it elſewhere. See Ossian, *Encycl.*

That any man ſhould ſuppoſe Macpherſon, after his tranſlation of Homer, the *author* of the poems which he aſcribes to Oſſian, appears to us very extraordinary; and it is little leſs extraordinary, that any one ſhould, for a moment, believe in the exiſtence of *manuſcripts* of theſe poems of *very high* antiquity. Part of them he undoubtedly received in manuſcript from Macdonald of Clanronald; but we can affirm, on the beſt authority, that the ſaid manuſcript was written at different times by the Macvurichs, hereditary bards to that family. He may likewiſe have received ſhort manuſcripts elſewhere; but every Highland gentleman of learning and of candour (and none elſe have a right to decide on this queſtion), declares, that by much the greater part of the poems had been preſerved in fragments and popular ſongs from a very remote age by oral tradition. To theſe fragments Macpherſon and his aſſociates (A) gave form; and it was by uniting together fragments of different ages, that he inadvertently furniſhed Gibbon and others with the opportunity of objecting, that the poems are ſometimes inconſiſtent with the truth of hiſtory. This, however, is no ſolid objection to their authenticity; for every Weſt Highlander ſixty years of age remembers to have heard, in his youth, great part of thoſe poems repeated by old men; and is confident that, many centuries ago, the names of *Fiune Mackuil* (Fingal), and of Oſſian's other heroes and heroines, were as familiar to a Highland ear, as the names of Agamemnon, Hector, Helen, &c. were to a Grecian ear at the time when the poems of Homer were reduced into their preſent form. For the ſubſtance of the poems, this is ſuch evidence as none will reject who does not prefer his own cobweb theories to the united teſtimony of a whole people.

With reſpect to authenticity, the poems of Oſſian have indeed been compared with the poems of Rowley; but the compariſon is abſurd. The poems of the Celtic bard were not found in an old cheſt, and preſented to a people who had never before heard either of them or of their author; they were the popular ſongs and traditions of ages collected together, and reduced into form, with additions occaſionally made by the tranſlator. It is ridiculous to aſk how theſe ſongs and ſtories could be ſo long preſerved among a rude and illiterate people; for it is only among ſuch a people, whoſe objects of purſuit are too few to occupy all their attention, that the exploits of their anceſtors can be handed down by tradition; and the moſt ſerious objection which we have ever met with to the tranſlator's account of the origin of the poems, ariſes from his having pretended that he received the greater part of them in old manuſcripts.

After the publication of Oſſian's poems, by which we have reaſon to believe that he gained twelve hundred pounds, Mr Macpherſon was called to an employment which withdrew him, for ſome time, both from the muſes and from his country. Captain Johnſtone was appointed governor of Penſacola, and Mr Macpherſon accompanied him as his ſecretary, being at the ſame time made ſurveyor-general of the Floridas. If our memory does not deceive us, ſome difference aroſe between the principal and his dependant, and they parted before their return to England. Having contributed his aid to the ſettlement of the civil government of that colony, he viſited ſeveral of the Weſt India iſlands, and ſome of the provinces of North America, and returned to England in the year 1766, where he retained for life his ſalary as ſurveyor, which we believe was L. 200 a-year.

He ſoon returned to his ſtudies, and in 1771 produced *An Introduction to the Hiſtory of Great Britain and Ireland*, 4to; a work which he ſays, "without any of the ordinary incitements to literary labour, he was induced to proceed in by the ſole motive of private amuſement." The ſubject of this performance, it might reaſonably be ſuppoſed, would not excite any violent controverſial acrimony; yet neither it nor its author could eſcape from ſeveral moſt groſs and bitter invectives, for ſome of which he perhaps gave too great occaſion.

His next performance produced him neither reputation nor profit. In 1773 he publiſhed, *The Iliad of Homer*, tranſlated in two volumes 4to; a work fraught with vanity and ſelf-conſequence, and which met with the moſt mortifying reception from the public. It was condemned by the critics, ridiculed by the wits, and neglected by the world. Some of his friends, and particularly Sir John Elliott, endeavoured to reſcue it from contempt, and force it into notice. Their ſucceſs was not equal to their efforts.

About this time ſeems to be the period of Mr Macpherſon's literary mortifications. In 1773 Dr Johnſon and Mr Boſwell made the tour to the Hebrides; and in the courſe of it, the former took ſome pains to examine into the proofs of the authenticity of Oſſian. The reſult of his inquiries he gave to the public in 1775, in his narrative of the tour; and his opinion was unfavourable. "I believe they (*i. e.* the poems, ſays he), never exiſted in any other form than that which we have ſeen. The editor or author never could ſhew the original; nor can it be ſhewn by any other. To revenge reaſonable incredulity by refuſing evidence, is a degree of inſolence with which the world is not yet acquainted; and ſtubborn audacity is the laſt refuge of guilt. It would be eaſy to ſhew it if he had it. But whence could it be had? It is too long to be remembered, and the language had formerly nothing written. He has doubtleſs inſerted names that circulate in popular ſtories, and may have tranſlated ſome wandering ballads, if any can be found; and the names and ſome of the images being recollected, make an inaccurate auditor imagine that he has formerly heard the whole."

Again, he ſays, "I have yet ſuppoſed no impoſture but in the publiſher; yet I am far from certainty, that ſome tranſlations have not been lately made, that

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(A) We have been aſſured that he had aſſociates: and that for the deſcription of Cuchullin's chariot in particular he was indebted to Mr Macpherſon of *Stramaſhie*; a man of native genius, and though not poſſeſſed of very extenſive erudition, well acquainted with Gaelic poetry.

may now be obtruded as parts of the original work.

"Credulity on the one part is a ſtrong temptation to deceit on the other, eſpecially to deceit of which no perſonal injury is the conſequence, and which flatters the author with his own ingenuity. The Scots have ſomething to plead for their eaſy reception of an improbable fiction: they are ſeduced by their fondneſs for their ſuppoſed anceſtors. Neither ought the Engliſh to be much influenced by Scotch authority; for of the paſt and preſent ſtate of the whole Erſe nation, the Lowlanders are at leaſt as ignorant as ourſelves. To be ignorant is painful; but it is dangerous to quiet our uneaſineſs by the deluſive opiate of haſty perſuaſion."

Theſe reaſonings, if reaſonings they can be called, might have been eaſily anſwered, had not Macpherſon pretended to the poſſeſſion of at leaſt one manuſcript which certainly never exiſted. He did not, however, attempt to anſwer them; but adopted a mode of proceeding which tended only to convince the world that Johnſon's opinion had ſome foundation, and that the editor of Oſſian had more imagination than ſound judgement. Prompted by his evil genius, he ſent a menacing letter to his illuſtrious antagoniſt, which produced the following brief but ſpirited reply:

"Mr James Macpherſon, No date.

"I received your fooliſh and impudent letter. Any violence that ſhall be offered to me, I will do my beſt to repel; and what I cannot do for myſelf, the law ſhall do for me; for I will not be hindered from expoſing what I think a cheat, by the menaces of a ruffian. What! Would you have me retract? I thought your work an impoſition: I think ſo ſtill; and, for my opinion, I have given reaſons, which I dare you to refute. Your abilities, ſince your *Homer*, are not ſo formidable; and what I hear of your morality, inclines me to believe rather what you ſhall prove than what you ſhall ſay."

Whether this letter ſhewed to Macpherſon the imprudence of his conduct, or that he had been made ſenſible of his folly by the interpoſition of friends, we know not; but certain it is, we hear no more afterwards of this ridiculous affair, except that our author is ſuppoſed to have aſſiſted Mr Macnicol in an anſwer to Dr Johnſon's Tour, printed in 1779. This ſuppoſition we are inclined to conſider as well-founded, becauſe we have been told by a gentleman of veracity, that Mr Macnicol affirms, that the ſcurrility of his book, which conſtitutes a great part of it, was inſerted, unknown to him, after the manuſcript was ſent for publication to London.

In 1775 Mr Macpherſon publiſhed *The Hiſtory of Great Britain from the Reſtoration to the Acceſſion of the Houſe of Hanover*, in two volumes 4to; a work in our opinion of great merit, though by one party it has been induſtriouſly, and, we are ſorry to add, too ſucceſsfully, decried. As an hiſtorian, our author could not indeed boaſt the attic elegance of a Robertſon, the ſplendour of a Gibbon, or the philoſophical profundity of a Hume; but his *ſtyle*, though it has ſometimes been the avowed, was not the real, cauſe of the coldneſs with which his hiſtory was received. The writer of this ſketch once ſaw a gentleman of rank, and of the Whig intereſt, turn over one of Macpherſon's volumes, and heard him ſay, upon ſhutting the book, "I cannot bear that work." He was aſked if he thought the narrative falſe? and he replied, "No! It is too true; but I cannot bear it, becauſe it gives me a bad opinion of thoſe great men to whom I have been accuſtomed to look back with reverence as to the ſaviours of my country."

That it has been abhorred by others on the ſame account, we have not a doubt; and yet language has no name too contemptuous for thoſe who will not follow truth whitherſoever ſhe may lead them; or who, on the abſurd pretence of having already made up their minds, will not ſtudy the evidence on both ſides of a diſputed queſtion in our national hiſtory. A man needs not ſurely diſapprove of the Revolution, or of the ſubſequent ſettlements, though he ſhould find complete proofs that Danby and Sunderland were crooked politicians, that Marlborough was ungrateful, or even that King William himſelf was not that upright and diſintereſted character which from their infancy they have been taught to believe. It is no uncommon thing for Divine Providence to accompliſh good ends by wicked inſtruments. Every Proteſtant ſurely conſiders the Reformation as one of the moſt bleſſed events that have taken place in the world ſince the firſt preaching of the goſpel of Chriſt; yet he would be a hardy champion who ſhould undertake to vindicate the motives which influenced the conduct of the firſt reformers—of Henry VIII. for inſtance, or even of Luther himſelf. And why may not the Revolution be conſidered as in the higheſt degree beneficial to the country, though the conduct of ſome of thoſe who brought it about ſhould be found to be ſuch as Macpherſon repreſents it?

That author certainly acted with great fairneſs; as together with the hiſtory he publiſhed the proofs upon which his facts were founded, in two quarto volumes, intitled, *Original Papers, containing the ſecret Hiſtory of Great Britain, from the Reſtoration to the Acceſſion of the Houſe of Hanover; to which are prefixed, Extracts from the Life of James II. as written by himſelf.* Theſe papers were chiefly collected by Mr Carte, but are not all of equal authority. They, however, clear up many obſcurities, and ſet the characters of many perſons in paſt times in a different light from that in which they have been uſually viewed. On this account we have no heſitation to ſay, that he who is capable of ſacrificing prejudice to truth, and wiſhes to underſtand the politics of the reigns of James, and William, and Anne, ſhould ſtudy with care the volumes of Macpherſon.

Soon after this period, the tide of fortune flowed very rapidly in Mr Macpherſon's favour, and his talents and induſtry were amply ſufficient to avail himſelf of every favourable circumſtance which aroſe. The reſiſtance of the Colonies called for the aid of a ready writer to combat the arguments of the Americans, and to give force to the reaſons which influenced the conduct of government, and he was ſelected for the purpoſe. Among other things (of which we ſhould be glad to receive a more particular account), he wrote a pamphlet, which was circulated with much induſtry, intitled, *The Rights of Great Britain aſſerted againſt the Claims of the Colonies; being an Anſwer to the Declaration of the General Congreſs*, 8vo, 1776, and of which many editions were publiſhed. He alſo was the author of *A ſhort Hiſtory of Oppoſition during the laſt Seſſion of Parliament*,

Parliament, 8vo, 1779; a pamphlet which, on account of its merit, was by many aſcribed to Mr Gibbon.

But a more lucrative employment was conferred on him about this time. He was appointed agent to the nabob of Arcot, and in that capacity exerted his talents in ſeveral appeals to the public in behalf of his client. Among others, he publiſhed, *Letters from Mahommed Ali Chan, Nabob of Arcot, to the Court of Directors; to which is annexed, a State of Facts relative to Tanjore, with an Appendix of Original Papers*, 4to, 1777; and he was ſuppoſed to be the author of *The Hiſtory and Management of the Eaſt India Company from its Origin in* 1600 *to the preſent Times*, vol. i. containing the affairs of the Carnatic, in which the rights of the nabob are explained, and the injuſtice of the Company proved, 4to, 1779.

In his capacity of agent to the nabob, it was probably thought requiſite that he ſhould have a ſeat in the Britiſh Parliament. He was accordingly in 1780 choſen member for Camelford; but we do not recollect that he ever attempted to ſpeak in the Houſe. He was alſo rechoſen in 1784 and 1790.

He had purchaſed, we think before the year 1790, an eſtate in the pariſh in which he was born; and changing its name from *Retz* to *Belville*, built on it a large and elegant manſion, commanding a very romantic and pictureſque view; and thither he retired, when his health began to fail, in expectation of receiving benefit from the change of air. He continued, however, to decline; and after lingering ſome time, died at his ſeat at Belville, in Inverneſs, on the 17th of February 1796.

He appears to have died in very opulent circumſtances; and by his will, dated June 1793, gave various annuities and legacies to ſeveral perſons to a great amount. He alſo bequeathed L. 1000 to John Mackenzie of Figtree-Court, in the Temple, London, to defray the expence of printing and publiſhing Oſſian in the original. He directed L. 300 to be laid out in erecting a monument to his memory in ſome conſpicuous ſituation at Belville, and ordered that his body ſhould be carried from Scotland, and interred in the Abbey Church of Weſtminſter, the city in which he had paſſed the beſt part of his life. His remains were accordingly taken from the place where he died, and buried in the Poets Corner of Weſtminſter church.

MAGMA is properly the *refuſe* of any ſubſtance which has been ſubjected to preſſure; but, in chemiſtry, the term is ſometimes uſed to denote a mixture of two or more bodies, reduced to the conſiſtence of dough or paſte.

MAGNETISM,

IN natural philoſophy.—Our intention in the preſent article was principally to give a more diſtinct account of the theory of Mr Æpinus than is contained in the article Magnetism of the *Encyclopedia Britannica*, referring for proof and illuſtration to the many facts contained in that article: but, on more mature conſideration, we concluded, that this method would fret and confuſe the reader by continual references, and leave but a feeble impreſſion at laſt. We have therefore preferred the putting the whole into the form of a ſhort treatiſe on magnetiſm, ſimilar to our ſupplementary article of Electricity. This, we hope, will be more perſpicuous and ſatisfactory; ſtill leaving to the reader the full uſe of all the information contained in the article Magnetism of the Dictionary.

1 Reaſons why the ancients were ignorant of natural philoſophy.

The knowledge which the antient naturaliſts poſſeſſed of this ſubject was extremely imperfect, and affords, we think, the ſtrongeſt proof of their ignorance of the true method of philoſophiſing; for there can hardly be named any object of phyſical reſearch that is more curious in itſelf, or more likely to engage attention, than the apparent life and activity of a piece of rude unorganiſed matter. This had attracted notice in very early times; for Thales attributed the characteriſtic phenomenon, the attraction of a piece of iron, to the agency of a mind or ſoul reſiding in the magnet. Philoſophers, as they were called, ſeem to have been contented with this lazy notice of a ſlight ſuggeſtion, unbecoming an inquirer, and rather ſuch as might be expected from the moſt incurious peaſant. Even Ariſtotle, the moſt zealous and the moſt ſyſtematic ſtudent of Nature of whoſe labours we have any account, has collected no information that is of any importance. We know that the general imperfection of ancient phyſics has been aſcribed to the little importance that was attached to the knowledge of the material world by the philoſophers of Greece and Rome, who thought human nature, the active purſuits of men, and the ſcience of public affairs, the only objects deſerving their attention. Moſt of the great philoſophers of antiquity were alſo great actors on the ſtage of human life, and deſpiſed acquiſitions which did not tend to accompliſh them for this dignified employment: but they have not given this reaſon themſelves, though none was more likely to be uppermoſt in their mind. Socrates diſſuades from the ſtudy of material nature, not becauſe it was unworthy of the attention of his pupils, but becauſe it was too difficult, and that certainty was not attainable in it. Nothing can more diſtinctly prove their ignorance of what is really attainable in ſcience, namely, the knowledge of the *laws of nature*, and their ignorance of the only method of acquiring this knowledge, viz. obſervation and experiment. They had entertained the hopes of diſcovering the *cauſes* of things, and had formed their philoſophical language, and their mode of reſearch, in conformity with this hopeleſs project. Making little advances in the diſcovery of the cauſes of the phenomena of material nature, they deſerted this ſtudy for the ſtudy of the conduct of man; not becauſe the diſcovery of cauſes was more eaſy and frequent here, but becauſe the ſtudy itſelf was more immediately intereſting, and becauſe any thing like ſuperior knowledge in it puts the poſſeſſor in the deſirable ſituation of an adviſer, a man of ſuperior wiſdom; and as this ſtudy was cloſely connected with morals, becauſe the fear of God is truly the beginning of wiſdom, the character of the philoſopher acquired an eminence and dignity which was highly flattering to human vanity. Their procedure in the moral and intellectual ſciences is ſtrongly marked with the ſame ignorance of the true method of philoſophiſing; for we rarely find them forming general propoſitions on copious inductions of facts in the conduct of men. They always proceed in the ſynthetic method, as if they were fully converſant in the firſt principles of human nature, and had nothing to do but to make the application, according to the eſtabliſhed forms of logic. While we admire, therefore, the ſagacity, the penetration, the candid obſervation, and the happy illuſtration, to be found in the works of the ancient moraliſts and writers on juriſprudence and politics, we cannot but lament that ſuch great men, frequently engaged in public affairs, and therefore having the fineſt opportunities for deducing general laws, have done ſo little in this way; and that their writings, however engaging and precious, cannot be conſidered as any thing more refined than the obſervations of judicious and worthy men, with all the diffuſeneſs and repetition of ordinary converſation. All this has ariſen from the want of a juſt notion of what is attainable in this department of ſcience, namely, the laws of intellectual and moral nature; and of the only poſſible method of attaining this knowledge, viz. obſervation and experiment, and the formation of general laws by the induction of particular facts.

2 Dr Gilbert was the firſt experimental enquirer about magnetiſm.

We have been led into theſe reflections by the inattention of the ancients to the curious phenomena of magnetiſm; which muſt have occurred in conſiderable and entertaining variety to any perſon who had taken to the experimental method. And we have hazarded theſe free remarks, expecting the acquieſcence of our readers, becauſe the ſuperior knowledge which we, in theſe later days, have acquired of the magnetical phenomena, were the firſt fruits of the true method of philoſophiſing. This was pointed out to the learned world in 1590 by our celebrated countryman Chancellor Bacon, in his two great works, the *Novum Organum Scientiarum*, and *De Argumentis Scientiarum*. Dr Gilbert of Colcheſter, a philoſopher of eminence in many reſpects, but chiefly becauſe he had the ſame juſt views of philoſophy with his noble countryman, publiſhed about the ſame time his *Phyſiologia Nova, ſeu Tractatus de Magnete et Corporibus magneticis*. In the introduction, he recounts all the knowledge of the ancients on the ſubject, and their ſupine inattention to what was ſo entirely in their hands; and the impoſſibility of ever adding to the ſtock of uſeful knowledge, ſo long as men imagined themſelves to be philoſophiſing while they were only repeating a few cant words, and the unmeaning phraſes of the Ariſtotelian ſchool. It is curious to remark the almoſt perfect ſameneſs of Dr Gilbert's ſentiments and language with thoſe of Lord Bacon. They both charge, in a peremptory manner, all thoſe who pretend to inform others, to give over their dialectic labours, which are nothing but ringing changes on a few trite truths, and many unfounded conjectures, and immediately to betake themſelves to experiment. He has purſued this method on the ſubject of magnetiſm with wonderful ardour, and with equal genius and ſucceſs; for Dr Gilbert was poſſeſſed both of great ingenuity, and a mind fitted for general views of things. The work contains a prodigious number and variety of obſervations and experiments, collected with ſagacity from the writings of others, and inſtituted by himſelf with conſiderable expence and labour. It would indeed be a miracle, if all Dr Gilbert's general inferences were juſt, or all his experiments accurate. It was untrodden ground. But, on the whole, this performance contains more real information than any writing of the age in which he lived, and is ſcarcely exceeded by any that has appeared ſince. We may hold it with juſtice as the firſt fruits of the Baconian or experimental philoſophy.

This work of Dr Gilbert's relates chiefly to the loadſtone, and what we call magnets, that is, pieces of ſteel which have acquired properties ſimilar to thoſe of the loadſtone. But he extends the term *magnetiſm*, and the epithet *magnetic*, to all bodies which are affected by loadſtones and magnets in a manner ſimilar to that in which they affect each other. In the courſe of his inveſtigation, indeed, he finds that theſe bodies are only ſuch as contain iron in ſome ſtate or other: and in proving this limitation, he mentions a great variety of phenomena which have a conſiderable reſemblance to thoſe which he allows to be magnetical, namely, thoſe which he called *electrical*, becauſe they were produced in the ſame way that amber is made to attract and repel light bodies. He marks with care the diſtinctions between theſe and the characteriſtic phenomena of magnets. He ſeems to have known, that all bodies may be rendered electrical, while ferrugineous ſubſtances alone can be made magnetical.

3 His treatiſe contains many diſcoveries.

It is not ſaying too much of this work of Dr Gilbert's to affirm, that it contains almoſt every thing that we know about magnetiſm. His unwearied diligence in ſearching every writing on the ſubject, and in getting information from navigators, and his inceſſant occupation in experiments, have left very few facts unknown to him. We meet with many things in the writings of poſterior inquirers, ſome of them of high reputation, and of the preſent day, which are publiſhed and received as notable diſcoveries, but are contained in the rich collection of Dr Gilbert. We by no means aſcribe all this to mean plagiariſm, although we know traders in experimental knowledge who are not free from this charge. We aſcribe it to the general indolence of mankind, who do not like the trouble of conſulting originals, where things are mixed with others which they do not want, or treated in a way, and with a painful minuteneſs, which are no longer in faſhion. Dr Gilbert's book, although one of thoſe which does the higheſt honour to our country, is leſs known in Britain than on the continent. Indeed we know but of two Britiſh editions of it, which are both in Latin; and we have ſeen five editions publiſhed in Germany and Holland before 1628. We earneſtly recommend it to the peruſal of the curious reader. He will (beſides the ſound philoſophy) find more facts in it than in the two large folios of Scarella.

After this moſt deſerved eulogy on the parent of magnetical philoſophy, it is time to enter on the ſubject.

4 We can only claſs the phenomena.

In mechanical philoſophy, a phenomenon is not to be conſidered as explained, unleſs we can ſhew that it is the certain reſult of the laws of motion applied to matter. It is in this way that the general propoſitions in phyſical aſtronomy, in the theory of machines, in hydraulics, &c. are demonſtrated. But the phenomena called *magnetical* have not as yet obtained ſuch an explanation. We do not ſee their immediate cauſe, nor can we ſay with confidence that they are the effects of any

any particular kind of matter, acting on the bodies either by impulſion or preſſure.

All that can be done here is to claſs the phenomena in the moſt diſtinct manner, according to their generality. In this we obtain a two-fold advantage. We may take it for granted that the moſt general phenomenon is the neareſt allied to the general cauſe. But, farther, we obtain by this method a true theory of all the ſubordinate phenomena. For a juſt theory is only the pointing out the general fact of which the phenomenon under conſideration is a particular inſtance. Beginning therefore with the phenomenon which comprehends all the particular caſes, we explain thoſe caſes in ſhewing *in what manner* they are included in the general phenomenon, and thus we ſhall be able to predict what will be the reſult of putting the body under conſideration into any particular ſituation. And perhaps we may find, in them all, coincidences which will enable us to ſhew that they are all modifications of a fact ſtill more general. If we gain this point, we ſhall have eſtabliſhed a complete theory of them, having diſcovered the general fact in which they are all comprehended. Should we for ever remain ignorant of the cauſe of this general fact, we have nevertheleſs rendered this a complete branch of mechanical theory. Nay, we may perhaps diſcover ſuch circumſtances of reſemblance between this general fact and others, with which we are better acquainted, that we ſhall, with great probability at leaſt, be able to aſſign the cauſe of the general fact itſelf, by ſhewing the law of which it is a particular inſtance.

We ſhall attempt this method on the preſent occaſion.

5
First leading fact.
Iron arranges itſelf in a particular poſition.

The leading facts in magnetiſm are the two following:

1. If any oblong piece of iron, ſuch as a bar, rod, or wire, be ſo fitted, that it can aſſume any direction, it will arrange itſelf in a certain determinate direction with reſpect to the axis of the earth. Thus, if, in any part of Britain, an iron or ſteel wire be thruſt through a piece of cork, as repreſented in fig. 1. ſo as that the whole may ſwim level in water, and if it be laid in the water nearly north-weſt and ſouth-eaſt, it will ſlowly change its poſition, and finally ſettle in a direction, making an angle of about 25 degrees with the meridian.

Plate XXXIV.

This experiment, which we owe to Dr Gilbert (ſee B. I. ch. 11.), is delicate, and requires attention to many circumſtances. The force with which the iron tends toward this final poſition is extremely weak, and will be balanced by very minute and otherwiſe inſenſible reſiſtances; but we have never found it fail when executed as here directed. An iron wire of the ſize of an ordinary quill, and about eight or ten inches long, is very fit for the purpoſe. It ſhould be thruſt through the cork at right angles to its axis; and ſo adjuſted, by repeated trials, as to ſwim level or parallel to the horizon. The experiment muſt alſo be made at a great diſtance from all iron; therefore in a baſon of ſome other metal or earthen ware. It may ſometimes require a very long while before the motion begin; and if the wire has been placed at right angles to the direction which we have mentioned as final, it will never change its poſition: therefore we have directed it to be laid in a direction not too remote, yet very ſenſibly different from the final direction.

But this is not the true poſition affected by the iron rod. If it be thruſt through a piece of wood or cork perfectly ſpherical, in ſuch a manner that it paſſes thro' its centre, and if the centre of gravity coincide with this centre, and the whole be of ſuch weight as to remain in any part of the water, without either aſcending or deſcending, then it will finally ſettle in a plane inclined to the meridian about 25°, and the north end will be depreſſed about 73° below the horizon.

All this is equivalent with ſaying, that if any oblong piece of iron or ſteel be very nicely poiſed on its centre of gravity, and at perfect liberty to turn round that centre in every direction, it will finally take the poſition now mentioned.

We have farther to obſerve with regard to this experiment, that it is indifferent which end of the rod be placed toward the north in the beginning of the experiment. That end will finally ſettle toward the north; and if the experiment be repeated with the ſame rod, but with the other end north, it will finally ſettle in this new attitude. It is, however, not always that we find pieces of iron thus perfectly indifferent. Very frequently one end affects the northerly poſition, and we cannot make the other end aſſume its place: the cauſes of this difference will be clearly ſeen by and bye.

6
Magnetical poſition.

The poſition thus affected by a rod of iron is called by Dr Gilbert the MAGNETICAL POSITION OR DIRECTION. It is not the ſame, nor parallel, in all parts of the earth, as will be more particularly noticed afterwards.

7
Second fact.
Iron attracts and repels iron.

2. The other leading fact is this: When a piece of iron, lying in the *magnetical* poſition, or nearly ſo, and at perfect liberty to move in every direction, is approached by another oblong piece of iron, held nearly in the ſame poſition, it is attracted by it; that is, the moveable piece of iron will gradually approach to the one that is preſented to it, and will at laſt come into contact with it, and may then be ſlowly drawn along by it.

This phenomenon, although not ſo delicate as the former, is ſtill very nice, becauſe the attraction is ſo weak that it is balanced by almoſt inſenſible obſtructions. But the experiment will ſcarcely fail if conducted as follows: Let a ſtrong iron wire be made to float on water by means of a piece of cork, in the manner already deſcribed, having one end under water. See fig. 1. B.

When it is nearly in the magnetical poſition, bring the end of a pretty big iron rod, ſuch as the point of a new poker, within a quarter of an inch of its ſouthern end (holding the poker in a poſition not very different from the magnetical poſition), and hold it there for ſome time, not exactly ſouthward from it, but a little to one ſide. The floating iron will be obſerved to turn towards it with an accelerated motion; will touch it, and may then be drawn by it through the water in any direction. We ſhall have the ſame reſult by approaching the northern extremity of the floating iron with the upper end of the poker.

The ſame phenomenon may be obſerved by ſuſpending the firſt piece of iron by its middle by a long and ſlender hair or thread. The ſuſpenſion muſt be long, otherwiſe the ſtiffneſs of the hair or thread may be ſufficient for balancing the very ſmall force with which the pieces of iron tend toward each other. The phenomenon

non may alſo be obſerved in a piece of iron which turns freely on a fine point, like the needle of the mariner's compaſs.

In this, as in the former experiment, the ends of the pieces of iron are obſerved, in general, to be indifferent; that is, either end of the one will attract either end of the other. It often happens, however, that the ends are not thus indifferent, and that the end of the moveable piece of iron, inſtead of approaching the other, will be obſerved to recede from it, and appear to avoid it. We ſhall ſoon learn the cauſe of this difference in the ſtates of iron.

8 This action mutual.

It is ſcarcely neceſſary to remark, that we muſt infer from theſe experiments, that the action is mutual between the two pieces of iron. Either of them may be the moveable piece which approaches the other, manifeſting the attraction of that other. This reciprocity of action will be abundantly verified and explained in its proper place.

9 Not peculiar to magnets or loadſtone;

Theſe two facts were long thought to be peculiar to loadſtones and artificial magnets, that is, pieces of iron which have acquired this property by certain treatment with loadſtones; but they were diſcovered by Dr Gilbert to be inherent in all iron in its metallic ſtate; and were thought by him to be neceſſary conſequences of a general principle in the conſtitution of this globe. Theſe phenomena are indeed much more conſpicuous in loadſtones and magnets; and it is therefore with ſuch that experiments are beſt made for learning their various modifications.

10 But, in iron, is indifferent, and momentary, and in loadſtones it is fixed and determinate.

But there is another circumſtance, beſides the degree of vivacity, in which the magnetiſm of common iron and ſteel remarkably differs from that of a loadſtone or magnet. When a loadſtone or magnet is ſo ſupported as to be at liberty to take any poſition, it arranges itſelf in the magnetical direction, and *one determined end* of it ſettles in the northern quarter; and if it be placed ſo that the other end is in that ſituation, it does not remain there, but gradually turns round, and, after a few oſcillations, the *ſame end* ultimately ſettles in the north. This is diſtinctly ſeen in the needle of the mariner's compaſs, which is juſt a ſmall magnet prepared in the ſame way with all other magnets. The ſeveral ends of loadſtones or magnets are thus permanently the north or the ſouth ends; whereas we ſaid that either end of a piece of common iron being turned to the northern quarter, it finally ſettles there.

It is this circumſtance which has rendered magnetiſm ſo precious a diſcovery to mankind, by furniſhing us with the compaſs, an inſtrument by which we learn the different quarters of the horizon, and which thus tells the direction of a ſhip's courſe through the pathleſs ocean (ſee COMPASS and VARIATION, *Encycl.*); and alſo ſhews us the directions of the veins and workings in the deepeſt mines. It was natural therefore to call thoſe the north and ſouth ends of the mariner's needle, or of a loadſtone or magnet. Dr Gilbert called them the POLES of the loadſtone or magnet. He had found it convenient for the propoſed train of his experiments to form his loadſtones into ſpheres, which he called TERRELLÆ, from their reſemblance to this globe; in which caſe the north and ſouth ends of his loadſtones were the poles of the terrellæ. He therefore gave the name *pole* to that part of any loadſtone or magnet which thus turned to the north or ſouth. The denomination was adopted by all ſubſequent writers, and now makes a term in the language of magnetiſm.

11 POLES.

Alſo, when we approach either end of a piece of iron A to either end of another B, theſe ends mutually attract; or if either end of a magnet A be brought near either end of a piece of common iron, they mutually attract each other. But if we bring that end of a magnet A which turns to the north near to the *ſimilar* end of another magnet B, theſe ends will not attract each other, but, on the contrary, will repel. If the two magnets are made to float on pieces of wood, and have their north poles fronting each other, the magnets will retire from each other; and in doing ſo, they generally turn round their axes, till the north pole of one front the ſouth pole of the other, and then they run together. This is a very notable diſtinction between the magnetiſm of magnets and that of common iron; and whenever we ſee a piece of iron ſhew this permanent diſtinction of its ends, we muſt conſider it as a magnet, and conclude that it has met with ſome peculiar treatment.

It is not, however, ſtrictly true, that the poles of loadſtones or magnets are ſo fixed in particular parts of their ſubſtance, nor that the poles of the ſame name ſo conſtantly repel each other; for if a ſmall or weak magnet A have its pole brought near the ſimilar pole of a large or ſtrong magnet B, they are often found to attract when almoſt touching, although at more conſiderable diſtances they repel each other. But this is not an exception to the general propoſition; for when the north pole of A is thus attracted by the north pole of B, it will be found, by other trials, to have all the qualities of a ſouth pole, while thus in the neighbourhood of the north pole of B.

12 Magnetic FORCE and POLARITY.

The magnetic properties and phenomena are conveniently diſtinguiſhed into thoſe of FORCE and of POLARITY. Thoſe of the firſt claſs only were known to the ancients, and even of them their knowledge was extremely ſcanty and imperfect. They may all be claſſed under the following general propoſitions.

13 Similar poles repel, and diſſimilar poles attract, each other.

1. The ſimilar poles of two magnets repel each other with a force decreaſing as the diſtances increaſe.
2. The diſſimilar poles of two magnets attract each other with a force decreaſing as the diſtances increaſe.
3. Magnets arrange themſelves in a certain determinate poſition with reſpect to each other.

14 The law of attraction and repulſion is of difficult inveſtigation.

The firſt object of reſearch in our farther examination of theſe properties is the relation which is obſerved to obtain between the diſtances of the acting poles and their force of action. This has accordingly occupied much attention of the philoſophers, and numberleſs experiments have been made in order to aſcertain the law of variation, both of the attraction and the repulſion. A great number of theſe have been narrated in the article MAGNETISM of the *Encycl.* from which it appears that it has been a matter of great difficulty, and had not been aſcertained with certainty or preciſion when that article was publiſhed. It is obvious, from the nature of the thing, that the determination is very difficult, and the inveſtigation very complicated. We can only obſerve the ſimultaneous motion of the whole magnet; yet we know that there are four ſeparate actions coexiſting and contributing in different directions, and with different forces, to the ſenſible effect The force which we meaſure, in any way whatever, is compounded

pounded of four different forces, which we cannot ſeparate and meaſure apart; for the north pole of A repels the north pole of B, and attracts its ſouth pole, while the ſouth pole of A exerts the oppoſite forces on the ſame poles of B. The attraction which we obſerve is the exceſs of two unequal attractions above two unequal repulſions. The ſame might be ſaid of an obſerved repulſion. Nay, the matter is incomparably more complicated than this; becauſe, for any thing that we know, *every* particle of A acts on *every* particle of B, and is acted on by it; and the intenſity of thoſe actions may be different at the ſame diſtances, and is certainly different when the diſtances are ſo. Thus there is a combination of an unknown number of actions, each of which is unknown individually, both in direction and intenſity. The preciſe determination is therefore, in all probability, impoſſible. By preciſe determination, we mean the law of mutual action between two magnetic particles, or that preciſe function of the diſtance which defines the intenſity of the force; ſo that meaſuring the diſtance of the acting particles on the axis of a curve, the ordinates of the curve may have the proportions of the attractions and repulſions.

It is almoſt needleſs to attempt any deduction of the law of variation from the numerous experiments which have been publiſhed by different philoſophers. An ample collection of them may be ſeen in Scarella's treatiſe. Mr Muſchenbroek has made a prodigious number; but all are ſo anomalous, and exhibit ſuch different laws of diminution by an increaſe of diſtance, that we may be certain that the experiments have been injudicious. Attention has not been paid to the proper objects. Magnets of moſt improper ſhapes have been employed, and of moſt diffuſe polarity. No notice has been taken of a circumſtance which, one ſhould think, ought to have occupied the chief attention; namely, the joint action of four poles, of which the experiment exhibits only the complex reſult. A very ſlight reflection might have made the enquirer perceive, that the attractions or repulſions are not the moſt proper phenomena for declaring the preciſe law of variation; becauſe what we obſerve is only the exceſs of a ſmall difference of attractions and repulſions above another ſmall difference. Mr Hawkſbee and Dr Brook Taylor employed a much better method, by obſerving the deviations from the meridian which a magnet occaſioned in a compaſs needle at different diſtances. This is occaſioned by the difference of the two ſums of the ſame forces; and this difference may be made a hundred times greater than the other. But they employed magnets of moſt improper ſhapes.

15
Judicious experiments by Mr Lambert.

We muſt except from this criticiſm the experiments of Mr Lambert, recorded in the Memoirs of the Academy of Berlin for 1756, publiſhed in 1758. This moſt ſagacious philoſopher (for he highly merits that name) placed a mariner's needle at various diſtances from a magnet, in the direction of its axis, and obſerved the declination from the magnetic meridian produced by the magnet, and the obliquity of the magnet to the axis of the needle. Thus, was the action of the magnet ſet in oppoſition and equilibrium with the natural polarity of the needle. But the difficulty was to diſcover in what proportion each of thoſe forces was changed by their obliquity of action on this little lever. No man excelled Mr Lambert in addreſs in deviſing methods of mathematical inveſtigation. He obſerved, that when the obliquity of the magnet to the axis of the needle was 30°, it cauſed it to decline 15°. When the obliquity was 75°, the diſtance being the ſame, it declined 30°. Call the obliquity *o*, and the declination *d*, and let *f* be that function of the angle which is proportionable to the action. Alſo let *p* be the natural polarity of the needle, and *m* the force of the magnet. It is evident that

$$p \times f,\ 15 = m \times f,\ 30$$

And $p : m = f,\ 30 : f,\ 15$; for the ſame reaſon

$$p : m = f,\ 75 : f,\ 30$$

Therefore $f,\ 15 : f\ 30 = f,\ 30 : f,\ 75^{\circ}$.

But it is well known that

$$\text{Sine } 15 : \text{Sine } 30 = \text{Sine } 30 : \text{Sine } 75.$$

Hence Mr Lambert was led to conjecture, that the ſine was that function of the angle which was proportional to the action of magnetiſm on a lever. But one experiment was inſufficient for determining this point. He made a ſimilar compariſon of ſeveral other obliquities and declinations with the ſame diſtances of the magnet, and alſo with other diſtances; and he put it paſt all diſpute, that his conjecture was juſt.

Had Mr Lambert's experiments terminated here, it muſt be granted that he has made a notable diſcovery in the theory of the intimate nature of magnetiſm. It completely refutes all the theories which pretend to explain the action of a magnet by the impulſion of a ſtream of fluid, or by preſſure ariſing from the motion of ſuch a ſtream; for in this caſe the preſſure on the needle muſt have diminiſhed in the duplicate ratio of the ſine. The directive power with the angle 90 muſt be 4 times greater than with the angle 30°; whereas it was obſerved to be only twice as great. Magnetiſm does not act therefore by the impulſion or preſſure of a ſtream of fluid, but in the manner of a ſimple incitement, as we conceive attraction or repulſion to act.

Having aſcertained the effect of obliquity, Mr Lambert proceeded to examine the effect of diſtance; and, by a moſt ingenious analyſis of his obſervations, he diſcovered, that if we repreſent the force of the magnet by *f*, and the diſtance of the neareſt pole of the magnet from the centre of the needle by δ, and if *a* be a conſtant quantity, nearly equal to two-thirds of the length of the needle, we have *f* proportional to $\overline{\delta - a}^{2}$.

Mr Lambert found this hold with very great exactneſs with magnets ten times larger, and needles twice as ſhort. But he acknowledges, that it gives a very ſingular reſult, as if the action of a magnet were exerted from a centre beyond itſelf. He attributes this to its true cauſe, the ſtill great complication of the reſult, ariſing from the action of the remote pole of the magnet. He therefore takes another method of examination, which we ſhall underſtand by and bye, when we conſider the *directive* power of a magnet. We have mentioned this imperfect attempt chiefly on account of the unqueſtionable manner in which he has aſcertained the effect of obliquity, and the importance of this determination.

We have attempted this inveſtigation in a very ſimple manner. We got ſome magnets made, conſiſting of two balls connected by a ſlender rod. By a very particular mode of impregnation, we gave them a pretty good magnetiſm; and the force of each pole ſeemed to reſide almoſt in the centre of the ball. This was our object in giving them this ſhape. It reduced the examination both of the attractive and of the directive power to a very eaſy computation. The reſult was, that the force of each pole varied in the inverſe duplicate ratio of the diſtance. The error of this hypotheſis in no caſe amounted to $\frac{1}{15}$th of the whole. In computing for the phenomena of the directive power, the irregularities and deviations from this ratio were much ſmaller.

The previous knowledge of this function would greatly expedite and facilitate our farther inveſtigation: but we muſt content ourſelves with a very imperfect approximation, and with arriving at the deſired determination by degrees, and by a very circuitous route.

16 Attempt to explain the phenomena without a preciſe knowledge of this law.

It is a matter of experience, that when two magnets are taken, each of which is as nearly equal as poſſible in the ſtrength of both poles, then, if they are placed with their axes in one ſtraight line, and the north pole of one fronting the ſouth pole of the other, they attract each other with a force which diminiſhes as the diſtance increaſes; and this variation of force is regular, that is, without any ſudden changes of intenſity, till it becomes inſenſible. No inſtance has occurred of its breaking ſuddenly off when of any ſenſible force, but it appears to diminiſh continually like gravity. No inſtance occurs in which attraction is changed into repulſion.

But it is, moreover, to be particularly remarked, that, having made this obſervation with the north pole of A fronting the ſouth pole of B, if the experiment be repeated with the ſouth pole of A fronting the north pole of B, the reſults will be preciſely the ſame. And, laſtly, it is a matter of unexcepted experience, that the ſenſible action of A on B, meaſured by the force which is neceſſary for preventing the farther approach of B, is preciſely equal to the action of B on A. This is the caſe, however unequal the force of the two magnets may be; that is, although A may ſupport ten pounds of iron, and B only ten ounces.

Now, the ſimpleſt view we can take of this experiment is, by ſuppoſing the whole action of one end or pole of a magnet to be exerted at one point of it. This will give us four actions of A on B, accompanied by as many equal and oppoſite actions of B on A. It is plain that we may content ourſelves with the inveſtigation of one only of theſe ſets of actions.

What we obſerve is the exceſs of the attractions of the poles of A for the diſſimilar poles of B above the repulſions of the ſame poles of A for the ſimilar poles of B. At all diſtances there is ſuch an exceſs. The ſum of the attractions exceeds the ſum of the repulſions competent to every diſtance.

Now this will really happen, if we ſuppoſe that the poles of a magnet are of equal ſtrength, and that, however theſe different magnets differ in ſtrength, they have the ſame law of diminution by an increaſe of diſtance. The firſt circumſtance is a very poſſible thing, and the laſt is demonſtrated by the obſerved equality of action and reaction. Every thing will now appear very plain, by repreſenting (as we did in ELECTRICITY, *Suppl.* n° 44, &c.) the intenſities of attraction and repulſion by the ordinates of a curve, of which the abſciſſæ repreſent the diſtances of the acting poles.

Therefore let A and B (fig. 2.) repreſent the two magnets, placed with their four poles S, N, *s*, *n*, in a ſtraight line. In the ſtraight line O *q* take O *m*, O *p*, O *n*, O *q*, reſpectively equal to N *s*, N *n*, S *s*, S *n*; and let MPNQ be a curve line, having O *q* for its axis and aſſymptote; and let the curve, in every part, be convex towards its axis. Then draw the ordinates *m* M, *p* P, *n* N, *q* Q, to the curve. Theſe ordinates will repreſent the intenſities of the forces exerted between the poles of the magnets, in ſuch a manner as to fulfil all the conditions that are really obſerved: For *m* M repreſents the attraction of the north pole N of the magnet, A for the ſouth pole *s* of the magnet B; *p* P repreſents the repulſion of N for *n*; *n* N repreſents the repulſion of S for *s*; and *q* Q repreſents the attraction of S for *n*. The diſtance between *m* and *n*, or between *p* and *q*, is equal to the length of the magnet A, and *m p*, or *n q*, is equal to that of B. M *m*, P *p*, and N *n*, Q *q*, are pairs of equidiſtant ordinates. It ſurely requires only the inſpection of the figure to ſee that, in whatever ſituation along the axis we place thoſe pairs of equidiſtant ordinates, the ſum of M *m* and Q *q* will always exceed the ſum of P *p* and N *n*; that is, the ſum of the attractions will always exceed that of the repulſions. This will not be the caſe if the curve, whoſe ordinates are proportional to the forces, have a point Z of contrary flexure, as is repreſented by the dotted curve P′ZQ′. For this curve, having O *q* for its aſſymptote (in order to correſpond with forces which diminiſh continually by an increaſe of diſtance, but do not abruptly ceaſe) muſt have its convexity turned toward this aſſymptote in the remote parts. But there will be an arch MPZ between Z and O, which is concave toward the aſſymptote. In which caſe, it is poſſible that M *m* + Q *q* ſhall be leſs than P *p* + N *n*; and then the repulſions will exceed the attractions; which is contrary to the whole train of obſervation.

It may be thought, that if the repulſion exerted between two particles be always leſs than the attraction at the ſame diſtance, the phenomena will be accounted for, although the law of action be not repreſented by ſuch a curve as has been aſſumed. Undoubtedly they will, while the diſſimilar poles front each other. But the reſults of ſuch a ſuppoſition will not agree with the phenomena while the ſimilar poles front each other: For it is an uncontradicted fact, that when two fine hard magnets, whoſe poles are nearly or exactly of equal vigour, have their ſimilar poles fronting each other, the repulſions fall very little ſhort of the attractions at the ſame diſtances when their poſition is changed: When the diſtances are conſiderable, ſcarcely any difference can be obſerved in the beginning of the experiment. The differences, alſo, which are obſerved at ſmaller diſtances, are obſerved to augment by continuing the magnets in their places without changing their diſtances; and therefore ſeem to ariſe from ſome change produced by each on the magnetiſm of the other. And, accordingly, if we invert one of the magnets, we ſhall find that the attractions have been diminiſhed as much as the repulſions. Now, the conſequences of magnetic repulſion, being always weaker than attraction, would be the reverſe of this. The differences would appear moſt remarkable in the greater diſtances, and magnets might be found which repel at ſmall diſtances, and attract at greater diſtances; which is contrary to all obſervation.

From all this it follows, with ſufficient evidence for our preſent purpoſe, that the function of the diſtance which expreſſes the law of magnetic action muſt be repreſented by the ordinates of a curve of the hyperbolic kind, referred to its aſſymptote as an axis; and therefore always convex toward this axis. We think it alſo ſufficiently clear, that the conſequences which we have deduced from the ſimple ſuppoſition of four acting points, inſtead of the combined action of every particle, may be adopted with ſafety. For they would be juſt, if there were only thoſe four particles; they would be juſt with reſpect to another four particles—therefore they would be juſt when theſe are joined; and ſo on of any number. Therefore the curve, whoſe ordinates expreſs the mean action of each pole, as if exerted by its centre of effort, will have the ſame general form: It will be convex toward its aſſymptotic axis.

It will greatly aid our conceptions of the combined actions of the four magnetic poles, if we notice ſome of the primary properties of a curve of this kind, limited by no other condition.

17 Unqueſtionable inferences from the phenomena.

Draw the chords MQ, PN, MP, NQ. Biſect them in B, D, E, F, and join EF. Draw the ordinates Ee Ff, and BDb (cutting EF in C). Draw Pu parallel to the axis, cutting Ee in ι. Draw alſo Qi parallel to the axis, cutting Ff in φ. Alſo draw FHL parallel to the axis, and Pot parallel to QN; and draw PLl, and Pex, cutting Mm in l and x.

Let each ordinate be repreſented by the letter at its interſection with the axis. Thus, the ordinates Mm and Qq may be repreſented by m and q, &c.

Becauſe MP is biſected in E, Mt is double of Eι; Ml is double of EL; Mx is double of Ee. Alſo, becauſe Pt is parallel to QN, and Pu to Qi, we have ιu = Ni. From theſe premiſes, it is eaſy to perceive, that,

1. $Bb = \frac{m+q}{2}$.
2. $Db = \frac{p+n}{2}$.
3. $BD = \frac{\overline{m+q} - \overline{p+n}}{2}$.
4. $Mu = m - p$.
5. $ut = n - q$.
6. $Mt = \overline{m-p} - \overline{n-q}$.
7. $Ee = \frac{m+p}{2}$.
8. $Ff = \frac{n+q}{2}$.
9. $Ml = \overline{m+p} - \overline{n+q}$.
10. $EL = \frac{m+p-n+q}{2}$.
11. $CD = \frac{\overline{m+q} - \overline{p+n}}{4}$.
12. $CH = \frac{\overline{m+p} - \overline{n+q}}{4}$.

Theſe combinations will ſuggeſt to the attentive reader the explanation of many modifications of the combined action of the four poles of two magnets. They are all comprehended in one propoſition, which it will be convenient to render familiar to the thought; namely, if two pairs of equidiſtant ordinates be taken, the ſum of the two extremes exceeds that of the intermediate ones. $m + q$ is greater than $p + n$. Alſo, the difference between the pair neareſt to O exceeds the difference between the remote pair.

Now, conceiving theſe ordinates to repreſent the mutual actions of the magnetic poles, we ſee that their tendency to or from each other, or their ſenſible attractions or repulſions, are expreſſed by $\overline{m+q} - \overline{n+p}$; that is, by the exceſs of the ſum of the actions of the neareſt and moſt remote poles above the ſum of the actions of the intermediate diſtant poles. It will alſo be frequently convenient to conſider this tendency as repreſented by $\overline{m-p} - \overline{n-q}$; that is, by the exceſs of the difference of the actions of the neareſt pole of A on the two poles of B, above the difference of the actions of its remote pole on the ſame poles of B.

Let us now conſider ſome of the chief modifications of theſe actions.

18 Explanation of the obſerved attraction of magnets,

1. Let the diſſimilar poles front each other. It is plain that $m + q$ repreſent attractions, and that $p + n$ repreſent repulſions. Alſo $m + q$ is greater than $p + n$. Therefore the magnets will attract each other. This attraction is alſo repreſented by $\overline{m-p} - \overline{n-q}$.

Now $\overline{m+q} - \overline{p+n}$ is evidently equal to Mt, or to twice Eo, or to twice BD, or to four times CD.

This action will be increaſed,

1. By increaſing the ſtrength of either of the magnets. The action of the magnets is the combined action of each acting particle of the one on each acting particle of the other; and it is mutual. Therefore all the ordinates will increaſe in the ratio of the ſtrength of each magnet, and their ſums and differences will increaſe in the ſame ratio.

2. By diminiſhing the diſtance between the magnets. For this brings all the ordinates nearer to O, while their diſtances mp, pu, nq, remain as before. In this caſe it is plain, that Mu, the difference of Mm and Pp, will increaſe faſter than tu or Ni, the difference between Nn and Qq. Therefore Mt will increaſe; that is, the attraction will increaſe.

3. By increaſing the length of A, while the diſtance between them remains the ſame. For Om remaining the ſame, as alſo mp and nq, while nq is only removed farther from mp, it is plain Mu remains the ſame, and that Ni and tu are diminiſhed; therefore Mt muſt increaſe, or the attraction muſt increaſe.

4. By increaſing the length of B, the diſtance between them remaining the ſame. For this increaſes mp and nq; and conſequently increaſes Mu and tu. But Mu increaſes more than tu; and therefore Mt is increaſed, and the attraction or tendency is increaſed.

All theſe conſequences of our original ſuppoſition, that the magnetic action may be repreſented by the ordinates of a curve every where convex to an aſſymptotic axis, are ſtrictly conformable to obſervation.

19 And of their repulſions.

If we place the magnets with their ſimilar poles fronting each other, it is evident that the ordinates which expreſſed attractions in the former caſe, will now expreſs repulſions; and that the forces with which the magnets now repel each other, are equal to thoſe with which they attracted when at the ſame diſtances. When the experiments are made with good loadſtones, or very fine magnets, tempered extremely hard, and having the energy of their poles ſenſibly reſiding in a ſmall ſpace very near the extremities, the reſults are alſo very nearly ly conformable to this mathematical theory; but there is generally a weaker action. The magnets ſeldom repel as ſtrongly as they attract at the ſame diſtance; at leaſt when theſe diſtances are ſmall. If one or both of the magnets is ſoft, or if one of them be much more vigorous than the other, there are obſerved much greater deviations from this theory The repulſions are *conſiderably* weaker than the attractions at the ſame diſtance, and the law of variation becomes extremely different. When placed at very conſiderable diſtances, they repel. As the magnet B is brought nearer to A, the repulſion increaſes, agreeably to the theory, but not ſo faſt. Bringing them ſtill nearer, the repulſion ceaſes to increaſe, then gradually diminiſhes, and frequently vaniſhes altogether, before the magnets are in contact; and when brought ſtill nearer, it is changed into attraction.

20 Seeming exceptions obviated.

But more careful obſervation ſhews, that this anomaly does not invalidate the theory. It is found that the vigour of the magnets is permanently changed by this proceſs. The magnets act on each other in ſuch a way as to weaken each other's magnetiſm. Nay, it frequently happens, that the weaker or the ſofter of the two has had its magnetiſm changed, and that the pole neareſt to the other has changed its nature. While they are lying in contact, or at ſuch a diſtance that they attract, although their ſimilar poles front each other, it is found that the pole of one of them is really changed; although it may ſometimes recover its former ſpecies again, but never ſo vigorouſly as when the other magnet is removed. In ſhort, it is obſerved, that the magnetiſm is diminiſhed in all experiments in which the magnets repel each other, and that it is improved in all experiments in which they attract.

We have hitherto ſuppoſed the magnets placed with their axes in one ſtraight line. If they are differently placed, we cannot aſcertain by this ſingle circumſtance of the law of magnetic action, whether they will attract or repel—we muſt know ſomewhat more of the variation of force by a change of diſtance.

21 DIRECTIVE POWER explained.

If the magnet B be not at liberty to approach toward A, or recede from it, but be ſo ſupported at its centre B that it can turn round it, it is very plain that it will retain the poſition in which it is drawn in the figure. For its ſouth pole s being more attracted by N than it is repelled by S, is, on the whole, attracted by the magnet A; and, by this attraction, it would vibrate like a pendulum that is ſupported at the centre B. In like manner, its north pole n is more repelled by N than it is attracted by S, and is, on the whole, repelled. The part Bn would therefore alſo vibrate like a pendulum round B. Thus each half of it is urged into the very poſition which it now has; and if this poſition be deranged a little, the attraction of sB toward A, and the repulſion of nB from it, would impel it toward the poſition sBn.

This will be very evident, if we put the magnet B into the poſition s'Bn', at right angles to the line AB. The pole s' and the pole n' are urged in oppoſite, and therefore conſpiring, directions with equal forces, very nearly at right angles to $n's'$, if the magnet B be ſmall. In any oblique poſition, the forces will be ſomewhat unequal, and account muſt be had of the obliquity of the action, in order to know the preciſe rotative momentum of the actions.

Dr Gilbert has given to this modification of the action of A on B, the name of VIS DISPONENS; which we may tranſlate by DIRECTIVE POWER or FORCE. Alſo, that modification of the tendency of B to or from A is called by him the VERTICITAS of B. We might call it the VERTICITY of B; but we think that the name POLARITY is ſufficiently expreſſive of the phenomenon; and as it has come into general uſe, we ſhall abide by it.

22 Its meaſure.

It is not ſo eaſy to give a general, and at the ſame time preciſe, meaſure of the directive power of A and polarity of B. The magnet B muſt be conſidered as a lever; and then the force tending to bring it into its ultimate poſition ns depends both on the diſtance of its poles from N and S, and alſo on the angle which the axis of B makes with the line AB. When the axis of B coincides with AB, the force acting on its poles, tending to *keep* them in that ſituation, is evidently $\overline{m+p}-\overline{n+q}$, and therefore may be repreſented by Ml (in fig. 2.), or by twice EL, or by four times CH. If B has the poſition n'Bs', perpendicular to AB, let the ordinates Ee and Ff cut the curve on I and K; and draw KL parallel to the axis (our figure cauſes this line almoſt to coincide with QL, and in all important caſes it will be nearly the ſame). In this caſe IL will expreſs one half of this force. Either of theſe eſtimations of this modification of the mutual action of the magnets, will be ſufficient for the objects we have in view.

23 How increaſed and diminiſhed.

The directive power of A, and the polarity of B, are increaſed,

1. By increaſing the ſtrength of one or both of the magnets. This is evident,

2. By diminiſhing the diſtance of the magnets. For this, by increaſing the ſum of Mm and Pp more than the ſum of Nn and Qq, muſt increaſe EL or Ml.

3. By increaſing the length of A. For this, by removing n and q farther from m and p, muſt depreſs the points L and l, and increaſe EL, or IL, or Ml.

4. By diminiſhing the length of B, while the diſtance Ns between the magnets remains the ſame. For this, by bringing p and q nearer to m and n, muſt increaſe Mm + Pp more than Nn + Qq. Or, by bringing Ee and Ff nearer to Mm and Nn, it muſt increaſe EL and Ml.

If the diſtance Nn between the pole of A and the remote pole of B remain the ſame, the directive force of A, and polarity of B, are diminiſhed by diminiſhing the length of B, as is eaſily ſeen from what has been juſt now ſaid. It is alſo diminiſhed, but in a very ſmall degree, by diminiſhing the length of B, when the diſtance between the centres of A and B remain the ſame. For, in this caſe, the ordinates Ie and Kf retain their places; but the points m and p approach to e; and this brings the interſection E of the ordinate and chord nearer to I, and diminiſhes EL, becauſe the point L is not ſo much depreſſed by the approach of F to K as E is depreſſed.

24 Circumſtances affecting the proportion of the attractive and directive powers.

But in all caſes, the *ratio* of the directive power of A to its attractive force, or of the polarity of B to its tendency to A, is increaſed by diminiſhing the length of B. For it is plain, that by diminiſhing mp and nq, while Ie and Kf keep their places, the point o is raiſed, and the point L is depreſſed; and therefore the ratio of EL to Eo, or of Ml to Mt, is increaſed. We even ſee that, by diminiſhing the length of B continually and without end, the ratio of $M l$ to $M \iota$ may be made to exceed any ratio that can be aſſigned.

25
The polarity of a ſmall magnet may be great while the attraction is inſenſible.

Now, ſince diminiſhing the length of B increaſes the ratio of the directive power of A to its attractive power, while increaſing the length of A increaſes both, and alſo increaſes the ratio of EL to E o (as is very eaſily ſeen), and ſince this increaſe may be as great as we pleaſe, it neceſſarily follows, that if the ſame very ſmall magnet B be placed at ſuch diſtances from a large and ſtrong magnet A, and from a ſmaller and leſs vigorous one C, as to have equal polarities to both, its tendency to A will be leſs than its tendency to C. It may even be leſs in any ratio we pleaſe, by ſufficiently diminiſhing the length of B.

Dr Gilbert obſerved this; and he expreſſes his obſervation by ſaying, that the directive power extends to greater diſtances than the attracting power. We muſt juſt conclude, that the laſt becomes *inſenſible* at ſmaller diſtances than the firſt. This will be found a very important obſervation. It may be of uſe to keep in mind, that the directive power of a magnet A on another magnet B, is the difference of the *ſums* of the actions of each pole of A on both poles of B; and the attractive power of A for another magnet B, is the difference of the *differences* of theſe actions.

It may be alſo remarked juſt now, that the directive force of A always exceeds its attractive force by the quantity $2(p-q)$. For their difference may be expreſſed by $t l$, which is equal to twice o L. Now ιe is equal to Pp, or to p; and ιL is equal to $Pp - Ff$, or to $Pp - Qq - F\iota$, or to $Pp - Qq - o\iota$. Therefore $oL = Pp - Qq$, and $tl = 2(Pp - Qq), = 2(p-q)$.

By inſpecting this figure with attention, we obtain indications of many intereſting particulars. If the lengths of the magnets A and B are the ſame, the point n in the axis of the curve will coincide with p. As the length of A increaſes, the part nq is removed farther from the part mp. The line $P\iota$ becomes leſs inclined to the axis, and is ultimately parallel to it, when n is infinitely remote. At this time L falls on e; ſo that the ultimate ratio of the attraction to the polarity is that of $E\iota$ to Ee, when the magnet A is infinitely long. It is then the ratio of the difference of the actions of the neareſt pole of A on the two poles of B to the ſum of theſe actions. Hence it follows, that when A is very great and B very ſmall, the polarity of B is vaſtly greater than its tendency to A. It may have a great polarity when its tendency is inſenſible.

The ratio of the polarity to the attraction alſo increaſes by increaſing the diſtance of the magnets while their dimenſions continue the ſame. This will appear, by remarking that the chords MP and NQ muſt interſect in ſome point w; and that when the four points m, p, n, and q, move off from O, keeping the ſame diſtances from each other, E o will diminiſh faſter than EL, and the ratio of EL to EO will continually increaſe.

Therefore when a ſmall magnet B is placed at ſuch a diſtance from a great magnet A, and from a ſmaller one C, as to have equal polarity to both, its tendency to C will exceed its tendency to A. For the polarities being equal, it muſt be farther from the great magnet; in which caſe the ratio of its polarity to its attraction is increaſed.

And this will alſo obtain if the magnets differ alſo in ſtrength. For, to have equal polarities, B muſt be ſtill farther from the great and powerful magnet.

For all theſe reaſons, a large and powerful magnet may exert a ſtrong directive power, while its attractive power is inſenſible.

26
Peculiarities of oblique poſitions of two magnets.

We have hitherto ſuppoſed the magnet B to be placed in the direction of the axis of A, and only at liberty to turn round its centre B. But let its centre be placed on the centre of A, as in fig. 3. it muſt evidently take a poſition which may be called ſubcontrary to that of A, the north pole of B turning toward the ſouth pole of A, and its ſouth pole turning toward the north pole of A.

The ſame thing muſt happen when the centre of B is placed in B, any where in the line AE perpendicular to NS. S attracts n with a force nb, while N repels n with a force no, ſomewhat ſmaller than nb. Theſe two compoſe the force nd. In like manner, the two forces se and sf, exerted by N and S on the pole s, compoſe the force sq. Now if the axis of the magnet B be parallel to NS, but the poles in a contrary poſition, and if each magnet be equally vigorous in both poles, the magnet B will retain this poſition; becauſe the forces nb and se are equal, as alſo the forces nc and sf. Theſe muſt compoſe two forces nd and sq, which are equal, and equally inclined to ns; and they will therefore be in equilibrio on this lever.

Let us now place the centre of the ſmall magnet in C, neither in the axis of the other, nor in the perpendicular AE. Let its north pole n point toward the centre of A. It cannot remain in this poſition; for N repels n with a force nc, while S attracts it with a force nb (ſmaller than nc, becauſe the diſtance is greater). Theſe two compoſe a force nd conſiderably different from the direction cn of its axis. In like manner, the ſouth pole s of the ſmall magnet is acted on by two forces se and sf, exerted by the two poles of A, which compoſe a force sq nearly equal and parallel to nd, but in a nearly oppoſite direction. It is plain that theſe forces muſt turn the ſmall magnet round its centre C, and that it cannot reſt but in a poſition nearly parallel to nd or sf. Its poſition is better repreſented by fig. 4. with its ſouth pole turned toward the north pole of the other magnet, and its north pole in the oppoſite direction.

What the preciſe poſition will be, depends on that function of the diſtance which is always proportional to the intenſity of the action; on the force of each of the poles of A, and on the length of the magnet B. Nay, even when we know this function, the problem is ſtill very intricate.

27
Means of acquiring a near meaſure of the law of action.

There are methods by which we may approximate to the function with ſucceſs. If the magnet B be indefinitely ſmall, ſo that we may conſider the actions on its two poles as equal, the inveſtigation is greatly ſimplified. For, in this caſe, each pole of the ſmall magnet B (fig. 5.) may be conceived as coinciding with its centre. Then, drawing NB, SB, and taking B b toward N, to repreſent the force with which N attracts the ſouth pole of B, and taking B c, in SB produced, to repreſent the force with which S repels the ſame pole, the compound force acting on this pole is B d, the diagonal of a parallelogram B b, dc. In like manner, we muſt take B e, in N b produced, and equal to B b, to repreſent the repulſion of N for the north pole of B, and B f equal to B c, to repreſent the attraction of S for this pole. The compound force will be B g, equal and oppoſite to B d. It follows evidently from this inveſtigation, that the ſmall magnet will not reſt in any poſition but dg. In this ſuppoſition, therefore, of extreme minuteneſs of the magnet B, one of the parallelograms is ſufficient. We may farther remark, that we have this approximation ſecure againſt any error ariſing from the ſuppoſition that all the action of each pole of B is exerted by one point. Although we ſuppoſe it diffuſed over a conſiderable portion of the magnet, ſtill the extreme minuteneſs of the whole makes the action, even on its extreme points, very nearly equal.

28 Law of action inveſtigated—MAGNETIC CURVE.

Hence may be derived a conſtruction for aſcertaining the poſition of the needle, when the function m of the diſtance is given, or for diſcovering this function by obſervation of the poſition of the needle.

Let NS (fig. 5. n° 2.) meet the direction of the needle in K. Make BG = BN, and draw NF, GE, SH, perpendicular to BK. It is evident that B b is to B c, or $b\,d$, as the ſine of the angle HBS to the ſine of KBN. Therefore, becauſe BG and BN are equal, we have B b : B c = GE : NF.

Therefore GE : NF = $BS^m : BN^m$
But SH : GE = BS : BN
Therefore SH : NF = $BS^{m+1} : BN^{m+1}$
And SK : NK = $BS^{m+1} : BN^{m+1}$

If magnetic action be inverſely as the diſtance, we have SK : NK = $BS^2 : BN^2$, and B is in the circumference of a circle which paſſes through S and N, and has BK for a tangent, as is plain by elementary geometry. If the action be inverſely as the ſquare of the diſtance, we have SK : NK = $BS^3 : BN^3$, and B is in the circumference of a curve of more difficult inveſtigation. But, as in the circle, the ſum of the angles BSN and BNS is a conſtant angle; ſo, in this curve, the ſum of the coſines of thoſe angles is a conſtant quantity. This ſuggeſts a very ſimple conſtruction of the curve. Let it paſs through the point T of the line AT, drawn from the centre of the magnet, perpendicular to its axis. Deſcribe the ſemicircle SPQN, cutting ST and NT in P and Q. Then, in order to find the point where any line SB cuts the curve, let it cut the ſemicircle in p, and apply the line N q = SP + NQ — S p, and produce it till it meet the line SB in B, which is a point in the curve; for it is evident that S p and N q are the coſines of BSN and BNS. We hope to give, by the help of a learned friend, the complete conſtruction of curves for every value of m, in an Appendix to this article. It will form a new and curious claſs, arranged by the functions of the angles at N and S.

But, in the mean time, we have determined the poſition of an indefinitely ſmall needle, in reſpect of a magnet of which we may conceive the polar activity concentrated in two points; and we may, on the other hand, make uſe of the obſerved poſitions of ſuch a needle and magnet for diſcovering the value of m. For, ſince $\frac{SK}{NK}=\frac{SB^{m+1}}{NB^{m+1}}$, it is plain that $m=\frac{\text{Log. } SK : NK}{\text{Log. } SB : NB}-1$. Thus, in an obſervation which the writer of this article made on a very ſmall needle, and a magnet having globular poles, and $8\frac{1}{3}$ inches between their centres, he found SB = $5\frac{1}{3}$, NB = $\frac{1}{3}$, SK = 11,49, and NK = 3,37. This gives m = 1,97, which differs from 2 only $\frac{1}{60}$th part. Finding it ſo very near the inverſe duplicate ratio of the diſtance, a circle VUZ was deſcribed, the circumference of which is the locus of SB : BN = 8 : 5,333. When the centre of the needle was placed anywhere in the circumference of this circle, it ſcarcely deviated from the point K, except when ſo far removed from the magnet that its natural polarity prevailed over the directive power of the magnet, or ſo near its middle that the action of the cylindrical part became very ſenſible.

It is plain that the length of the needle muſt occaſion ſome deviation from the magnetic direction, by deſtroying the perfect equality of action on its two poles. He therefore employed three needles of $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$ of an inch in length; and by noticing the differences of direction, he inferred what would be the direction, if the forces on each pole were preciſely equal. He had the pleaſure of ſeeing that the deviation from the inverſe duplicate ratio of the diſtances was ſcarcely perceptible.

Mr Lambert's experiments on the directive power of the magnet, narrated in his ſecond diſſertation in the 22d volume of the Memoirs of the Academy of Berlin, are the moſt valuable of all that are on record; and the ingenious addreſs with which they are conducted, and the inferences are drawn, would have done credit to Newton himſelf. We earneſtly recommend the careful peruſal of that Eſſay, as the moſt inſtructive of any that we have read. The writer of this found himſelf obliged to repeat all his former experiments, mentioned above, in Mr Lambert's manner, and with his precaution of keeping the needle in its natural poſition; a circumſtance to which he had not ſufficiently attended before. The new reſults were ſtill more conformable to his conjecture as to the law of variation. Mr Lambert cloſes his diſſertation with an hypotheſis, "that the force of each tranſverſe element of a magnet is as its diſtance from the centre, and its action on a particle of another magnet is inverſely as the ſquare of the diſtance." On this ſuppoſition, he calculates the poſition of a very ſmall needle, and draws three of the curves to which it ſhould be the tangent. Theſe are very exactly coincident with ſome that he obſerved. We tried this with ſeveral magnetic bars, and found it very conformable to obſervation in ſome magnets; but deviating ſo far in the caſe of other magnets, that we are convinced that there is no rule for the force of each tranſverſe element of a magnet, and that the magnetiſm is differently diſpoſed in different magnets. It was chiefly this which induced us to form the magnets employed in this reſearch of two balls united by a ſlender rod. Lichtenberg, in his notes on Erxleben's Natural Philoſophy, ſays, that there is a MS. of the celebrated Tobias Mayer in the library of the Academy of Gottingen, in which he aſſumes the hypotheſis above-mentioned, and gives a conſtruction of the magnetic curves founded on it, making them a kind of catenaria. The interior curves do indeed reſemble the catenaria, but the exterior are totally unlike. But there is no occaſion for much argument to convince us, that the firſt part of this hypotheſis is not only gratuitous, but unwarranted by any general phenomena. We know that a magnetical bar may have its magnetiſm very differently diſpoſed; for it may have more than two poles, and the intermediate poles *cannot* have this diſpoſition of the magnetiſm.

netiſm. Such a diſpoſition is perhaps poſſible; but is by no means general, or even frequent. We are diſpoſed to think, that permanent magnetiſm muſt have its intenſity diminiſhing in the very extremity of the bar. The reader may gueſs at our reaſons from what is ſaid in Electricity, *Suppl.* n° 222.

29 **Primary and secondary, or simple and compound curves.**

The following very curious and inſtructive phenomenon was the firſt thing which greatly excited the curioſity of the writer of this article, and long puzzled him to explain it. Indeed it was his endeavours to explain it which gradually opened up to him the theory of the mutual action of magnets contained in theſe paragraphs, and firſt gave him occaſion to admire the ſagacity of Dr Gilbert, and to ſee the connecting principle of the vaſt variety of obſervations and experiments which that philoſopher had made. It ſeems owing to the want of this connecting principle, that a book ſo rich in facts ſhould be ſo little read, and that ſo many of Dr Gilbert's obſervations have been publiſhed by others as new diſcoveries.

Amuſing himſelf in the ſummer 1758 with magnetic experiments, two large and ſtrong magnets A and B (fig. 6.), were placed with their diſſimilar poles fronting each other, and about three inches apart. A ſmall needle, ſupported on a point, was placed between them at D, and it arranged itſelf in the ſame manner as the great magnets. Happening to ſet it off to a good diſtance on the table, as at F, he was ſurpriſed to ſee it immediately turn round on its pivot, and arrange itſelf nearly in the oppoſite direction. Bringing it back to D reſtored it to its former poſition. Carrying it gradually out along DF, perpendicular to NS, he obſerved it to become ſenſibly more feeble, vibrating more ſlowly; and when in a certain point E, it had no polarity whatever towards A and B, but retained any poſition that was given it. Carrying it farther out, it again acquired polarity to A and B, but in the oppoſite direction; for it now arranged itſelf in a poſition that was parallel to NS, but its north pole was next to N, and its ſouth pole to S.

This ſingular appearance naturally excited his attention. The line on which the magnets A and B were placed had been marked on the table, as alſo the line DF perpendicular to the former. The point E was now marked as an important one. The experiments were interrupted by a friend coming in, to whom ſuch things were no entertainment. Next day, wiſhing to repeat them to ſome friends, the magnets A and B were again laid on the line on which they had been placed the day before, and the needle was placed at E, expecting it to be neutral. But it was found to have a conſiderable verticity, turning its north pole toward the magnet B; and it required to be taken farther out, toward F, before it became neutral. While ſtanding there, ſomething chanced to joggle the magnets A and B, and they inſtantly ruſhed together. At the ſame inſtant, the little magnet or needle turned itſelf briſkly, and arranged itſelf, as it had done the day before, at F, quivering very briſkly, and thus ſhewing great verticity. This naturally ſurpriſed the beholders; and we now found that, by gradually withdrawing the magnets A and B from each other, the needle became weaker—then became neutral—and then turned round on its pivot, and took the contrary poſition. It was very amuſing to obſerve how the ſimply ſeparating the magnets A and B, or bringing them together, made the needle aſſume ſuch a variety of poſitions and degrees of vivacity in each.

The needle was now put in various ſituations, in reſpect to the two great magnets; namely, off at a ſide, and not in the perpendicular DF. In theſe ſituations, it took an inconceivable variety of poſitions, which could not be reduced to any rule; and in moſt of them, it required only a motion of one of the great magnets for an inch or two, to make the needle turn briſkly round on its pivot, and aſſume a poſition nearly oppoſite to what it had before.

But all this was very puzzling, and it was not till after ſeveral months, that the writer of this article, having conceived the notion of the magnetic curves, was in a condition to explain the phenomena. With this aſſiſtance, however, they are very clear, and very inſtructive.

Nothing hinders us from ſuppoſing the magnets A and B perfectly equal in every reſpect. Let NHM, NEL, be two magnetic curves belonging to A; that is, ſuch that the needle arranges itſelf along the tangent of the curve. Then the magnet B has two curves SGK, SEI, perfectly equal, and ſimilar to the other two. Let the curves NHM and SGK interſect in C and F. Let the curves NEL and SEI touch each other in E.

The needle being placed at C, would arrange itſelf in the tangent of the curve KGS, by the action of B alone, having its north pole turned toward the ſouth pole S of B. But, by the action of A alone, it would be a tangent to the curve NHM, having its north pole turned away from N. Therefore, by the combined action of both magnets, it will take neither of theſe poſitions, but an intermediate one, nearly biſecting the angle formed by the two curves, having its north pole turned toward B.

But remove the needle to F. Then, by the action of the magnet A, it would be a tangent to the curve FM, having its north pole toward M. By the action of B, it would be a tangent to the curve KFG, having its north pole in the angle MFG, or turned toward A. By their joint action, it takes a poſition nearly biſecting the angle GFM, with its north pole toward A.

Let the needle be placed in E. Then, by the action of the magnet A, it would be a tangent to the curve NEL, with its north pole pointing to F. But, by the action of B, it will be a tangent to SEI, with its north pole pointing to D. Theſe actions being ſuppoſed equal and oppoſite, it will have no verticity, or will be neutral, and retain any poſition that is given to it.

The curve SEI interſects the curve NHM in P and Q. The ſame reaſoning ſhews, that when the needle is placed at P, it will arrange itſelf with its north pole on the angle SPH: but, when taken to Q, it will ſtand with its north pole in the angle EQM.

From theſe facts and reaſonings we muſt infer, that, for every diſtance of the magnets A and B, there will be a ſeries of curves, to which the indefinitely ſhort needle will always be a tangent. They will riſe from the adjoining poles on both ſides, croſſing diagonally the lozenges formed by the PRIMARY or SIMPLE curves, as in fig. 6. Theſe may be called COMPOUND or SECONDARY magnetic curves. Moreover, theſe ſecondary curves will be of two kinds, according as they paſs through the firſt or ſecond interſections of the primary curves, and the needle will have oppoſite poſitions when placed on them. Theſe two ſets of curves will be ſeparated by a curve GEH, in the circumference of which the needle will be neutral. This curve paſſes through the points where the primary curves touch each other. We may call this the *line of neutrality* or inactivity.

We now ſee diſtinctly the effect of bringing the magnets A and B nearer together, or ſeparating them farther from each other. By bringing them nearer to each other, the point E, which is now a point of neutrality, may be found in the *ſecond* interſection (ſuch as F) of two magnetic curves, and the needle will take a ſubcontrary poſition. By drawing them farther from each other, E may be in the *firſt* interſection of two magnetic curves, and the needle will take a poſition ſimilar to that of C.

If the magnets A and B are not placed ſo as to form a ſtraight line with their four poles, but have their axes making an angle with each other, the contacts and interſections of their attending curves may be very different from thoſe now repreſented; and the poſitions of the needle will differ accordingly. But it is plain, from what has been ſaid, that if we knew the law of action, and conſequently the form of the primary curves, we ſhould always be able to ſay what will be the poſition of the needle. Indeed, the conſideration of the ſimple curves, although it was the mean of ſuggeſting to the writer of this article the explanation of thoſe more complicated phenomena, is by no means neceſſary for this purpoſe. Having the law of magnetic action, we muſt know each of the eight forces by which the needle is affected, both in reſpect of direction and intenſity; and are therefore able to aſcertain the ſingle force ariſing from their compoſition.

Secondary curves of repulſion.

When the ſimilar poles of A and B are oppoſed to each other, it is eaſy to ſee, that the poſition of the needle muſt be extremely different from what we have been deſcribing. When placed anywhere in the line DF, between two magnets, whoſe north poles front each other in N and S, its north pole will always point away from the middle point D. There will be no neutral point E. If the needle be placed at P or Q, its north pole will be within the angle EPH, or FQI. This poſition of the magnets gives another ſet of ſecondary curves, which alſo croſs the primary curves, paſſing diagonally through the lozenges formed by their interſection. But it is the other diagonal of each lozenge which is a chord to theſe ſecondary curves. They will, therefore, have a form totally different from the former ſpecies.

30
Remarks on this inveſtigation.

The conſideration of this compounded magnetiſm is important in the ſcience, both for explaining complex phenomena, and for advancing our knowledge of the great deſideratum, the law of magnetic action. It ſerves this purpoſe remarkably. By employing a very ſmall needle, the points of neutrality aſcertain very nearly where the magnetic curves have a common tangent, and ſhews the poſition of this tangent. By placing the two magnets ſo as to form various angles with each other, we can, by means of theſe neutral points, know the poſition of the tangent in every point of the curve, and thus can aſcertain the form of the curve, and the law of action, with conſiderable accuracy. The writer of this article took this method; and the reſult confirmed him in the opinion, that it was in the inverſe duplicate ratio of the diſtances. The chief (perhaps the only) ground of error ſeemed to be the difficulty of procuring large magnets, having the action of each pole very much concentrated. Large magnets muſt be employed. He attempted to make ſuch, conſiſting of two ſpherical balls, joined by a ſlender rod. But he could not give a ſtrong magnetiſm to magnets of this form, and was forced to make uſe of common bars, the poles of which are conſiderably diffuſed. This diffuſion of the pole renders it very difficult to ſelect with propriety the points from which the diſtances are to be eſtimated, in the inveſtigation of the relation between the forces and diſtances.

He tried another method for aſcertaining this ſo much deſired law, which had alſo the ſame reſult. Having made a needle conſiſting of two balls joined by a ſlender rod, and having touched it with great care, ſo that the whole ſtrength of its poles ſeemed very little removed from the centres of the balls, he counted the number of horizontal vibrations which it made in a given time by the force of terreſtrial magnetiſm. He then placed it on the middle of a very fine and large magnet, placed with its poles in the magnetic meridian, the north pole pointing ſouth. In this ſituation he counted the vibrations made in a given time. He then raiſed it up above the centre of the large magnet, till the diſtance of its poles from thoſe of the great magnet were changed in a certain proportion. In this ſituation its vibrations were again counted. It was tried in the ſame way in a third ſituation, conſiderably more remote from the great magnet. Then, having made the proper reduction of the forces correſponding to the obliquity of their action, the force of the poles of the great magnet was computed from the number of vibrations. To ſtate here the circumſtances of the experiment, the neceſſary reductions, and the whole computations, would occupy ſeveral pages, and to an intelligent reader would anſwer little purpoſe. Mr Lambert's excellent diſſertation in the 22d vol. of the *Mem. de l'Acad. de Berlin*, will ſhew the prolixity and intricacy of this inveſtigation. Suffice it to ſay, that theſe experiments were the moſt conſiſtent with each other of any made by the writer of this article, with the view of aſcertaining the law of magnetic action; and it is chiefly from their reſult that he thinks himſelf authoriſed to ſay, with ſome confidence, that it is inverſely as the ſquare of the diſtance. Theſe experiments were firſt made in a rough way in 1769 and 1770. In 1775, obſerving that Mr Æpinus ſeemed to think the action inverſely as the diſtance (ſee his *Tentam. Theor. Electr. et Magn.* § 301. &c.), they were repeated with very great care; and to theſe were added another ſet of experiments, made with the ſame magnet and the ſame needle, placed not above the magnet, but at one ſide (but always in the line through the centre, perpendicular to the axis, ſo that the actions of the two poles might be equal). This diſpoſition evidently ſimplifies the proceſs exceedingly. The reſult of the whole was ſtill more ſatisfactory. This concluſion is alſo confirmed by the experiments of Mr Coulomb in the Memoirs of the Academy of Sciences at Paris for 1786 and 1787. It would ſeem therefore to be pretty well eſtabliſhed. Another method, which ſeems ſuſceptible of conſiderable accuracy, ſtill remains to be tried. It will be mentioned in due time.

Such then are the general laws obſerved in the mutual action of magnets. We think it ſcarcely neceſſary to enter into a farther detail of their conſequences, correſponding to the innumerable varieties of poſitions in which they may be placed with reſpect to each other. We are confident, that the ſenſible actions will always be found agreeable to the legitimate conſequences of the general propoſitions which we have eſtabliſhed in the preceding paragraphs. We proceed therefore to conſider ſome phyſical facts not yet taken notice of, which have great influence on the phenomena, and greatly aſſiſt us in our endeavours to underſtand ſomething of their remote cauſe.

31
Magnetiſm is temporary and periſhing.

Magnetiſm, in all its modifications of attraction, repulſion, and direction, is, in general, of a temporary or periſhing nature. The beſt loadſtones and magnets, unleſs kept with care, and with attention to certain circumſtances, are obſerved to diminiſh in their power. Natural loadſtones, and magnets made of ſteel, tempered as hard as poſſible, retain their virtue with greateſt obſtinacy, and ſeldom loſe it altogether, unleſs in ſituations which our knowledge of magnetiſm teaches us to be unfavourable to its durability. Magnets of tempered ſteel, ſuch as is uſed for watch-ſprings, are much ſooner weakened, part with a greater proportion of their force by ſimple keeping, and finally retain little or none. Soft ſteel and iron loſe their magnetiſm almoſt as ſoon as its producing cauſe is removed, and cannot be made to retain any ſenſible portion of it, unleſs their metallic ſtate ſuffer ſome change.

1. Hurt by improper poſition.

1. Nothing tends ſo much to impair the power of a magnet as the keeping it in an improper poſition. If its axis be placed in the magnetic direction, but in a contrary poſition, that is, with the north pole of it where the ſouth pole tends to ſettle, it will grow weaker from day to day; and unleſs it be a natural loadſtone, or be of hard tempered ſteel, it will, after no very long time, loſe its power altogether.

2. By heat; effects of thunder and electricity.

2. This diſſipation of a ſtrong magnetic power is greatly promoted by heat. Even the heat of boiling water affects it ſenſibly; and if it be made red hot, it is entirely deſtroyed. This laſt fact has long been known. Dr Gilbert tried it with many degrees of violent heat, and found the conſequences as now ſtated; but having no thermometers in that dawn of ſcience, he could not ſay any thing preciſe. He only obſerves, that it is deſtroyed by a heat not ſufficient to make it viſible in a dark room. Mr Canton found even boiling water to weaken it; but on cooling again the greateſt part was recovered.

3. By violent treatment.

3. What is more remarkable, magnetiſm is impaired by any rough uſage. Dr Gilbert found, that a magnet which he had impregnated very ſtrongly, was very much impaired by a ſingle fall on the floor; and it has been obſerved ſince his time, that falling on ſtones, or receiving any concuſſion which cauſes the magnet to ring or ſound, hurts it much more than beating it with any thing ſoft and yielding. Grinding a natural loadſtone with coarſe powders, to bring it into ſhape, weakens it much; and loadſtones ſhould therefore be reduced into a ſhape as little different from their natural form as poſſible; and this ſhould be done briſkly, cutting them with the thin diſks of the lapidary's wheel, cutting off only what is neceſſary for leaving their moſt active parts or poles as near their extremities as we can.

All theſe cauſes of the diminution of magnetiſm are more operative if the magnet be all the while in an improper poſition.

4. By other magnets.

4. Laſtly, magnetiſm is impaired and deſtroyed by placing the magnet near another magnet, with their ſimilar poles fronting each other. We have had occaſion to remark this already, when mentioning the experiments made with magnets in this poſition, for aſcertaining the general laws or variations of their repulſion. We there obſerved, that magnets ſo ſituated always weakened each other, and that a powerful magnet often changed the ſpecies of the neareſt pole of one leſs powerful. This change is recovered, in part at leaſt, when it has taken place in a loadſtone or a magnet of hard ſteel; but in ſpring tempered ſteel the change is generally permanent, and almoſt to the full extent of its condition while the magnets are together. It is to be remarked, that this change is gradual; and is expedited by any of the other cauſes, particularly by heat or by knocking.

32
Magnetiſm may be acquired,

On the other hand, magnetiſm is acquired by the ſame means, when ſome other circumſtanc[illegible] are attended to.

1. By magnetical poſition;

1. A bar of iron, which has long ſtood in the magnetic direction, or nearly ſo, will gradually acquire magnetiſm, and the ends will acquire the polarity correſponding to their ſituation. In this country, and the north of Europe, the old ſpindles of turret vanes, old bars of windows, &c. acquire a ſenſible magnetiſm; their lower extremity becoming a north pole, and the other end a ſouth pole. Gilbert ſays, that this was firſt obſerved in Mantua, in the vane ſpindle of the Auguſtine church—"*Vento flexa* (ſays he) *de prompta, et apothecario cuidam conceſſa, attrahebat ferrea ramenta, vi perquam inſigni.*" The upper bar of a hand rail to a ſtair on the north ſide of the higheſt part of the ſteeple of St Giles's church in Edinburgh is very magnetical; and the upper end of it, where it is lodged in the ſtone, is a vigorous ſouth pole. It is worth notice, that the parts of ſuch old bars acquire the ſtrongeſt magnetiſm when their metallic ſtate is changed by expoſure to the air, becoming foliated and friable. It would be worth while to try, whether the æthiops martialis, produced by ſteam in the experiments for decompoſing water, will acquire magnetiſm during its production. The pipe and the wires, which are converted into the ſhining æthiops, ſhould be placed in the magnetic direction.

2. By hammering;

2. If a bar of ſteel be long hammered while lying in the magnetic direction, it acquires a ſenſible magnetiſm (See Dr Gibert's plate, repreſenting a blackſmith hammering a bar of iron in the magnetic direction). The points of drills, eſpecially the great ones, which are urged by very great preſſure; and broaches, worked by a long lever, ſo as to cut the iron very faſt, acquire a ſtrong magnetiſm, and the lower end always becomes the north pole (*Phil. Tranſ.* xx. 417.) Even driving a hard ſteel punch into a piece of iron, gives it magnetiſm by a ſingle blow. In ſhort, any very violent ſqueeze given to a piece of tempered ſteel renders it magnetic, and its polarity correſponds with its poſition during the experiment. We can ſcarcely take up a cutting or boring tool in a ſmith's ſhop that is not magnetical. Even

ſoft ſteel and iron acquire permanent magnetiſm in this way. Iron alſo acquires it by twiſting and breaking. It is therefore difficult to procure pieces of iron or ſteel totally void of determinate and permanent magnetiſm; and this frequently mars the experiments mentioned in the firſt paragraphs of this article. The way therefore to enſure ſucceſs in theſe experiments is to deprive the rods of their accidental magnetiſm, by ſome of the methods mentioned a little ago. Let them be heated red hot, and allowed to cool while lying in a direction perpendicular to the magnetic direction (nearly E. N. E. and W. S. W. in this country).

3. By heating; 3. As heat is obſerved to deſtroy magnetiſm, ſo it may alſo be employed to induce it on ſubſtances that are ſuſceptible of magnetiſm. Dr Gilbert makes this obſervation in many parts of his work. He ſays, that the ores of iron which are in that particular metallic ſtate which he conſiders as moſt ſuſceptible of magnetiſm, will acquire it by long continuance in a red heat, if laid in the magnetic direction, and that their polarity is conformable to their poſition, that end of the maſs which is next the north becoming the north pole. He alſo made many experiments on iron and ſteel bars expoſed to ſtrong heats in the magnetical direction. Such experiments have been made ſince Gilbert's time in great number. Dr Hooke, in 1684, made experiments on rods of iron and ſteel one-fifth of an inch in diameter, and ſeven inches long. He found them to acquire permanent magnetiſm by expoſure to ſtrong heat in the magnetic direction, and if allowed to cool in that direction. But the magnetiſm thus acquired by ſteel rods was much ſtronger, and more permanent, if they were ſuddenly quenched with cold water, ſo as to temper them very hard. He found, that the end which was next to the north, or the lower end of a vertical bar, was always its permanent north pole. Even quenching the upper end, while the reſt was ſuffered to cool gradually, became a very ſenſible ſouth pole. No magnetiſm was acquired if this operation was performed on a rod lying at right angles to the magnetical direction.

In theſe trials the polarity was always eſtimated by the action on a mariner's needle, and the intenſity of the magnetiſm was eſtimated by the deviation cauſed in this needle from its natural poſition. Dr Gilbert made a very remarkable obſervation, which has ſince been repeated by Mr Cavallo, and publiſhed in the Philoſophical Tranſactions as a remarkable diſcovery. Dr Gilbert ſays, p. 69. "*Bacillum ferreum, valide ignitum appone verſorio excito; ſtat verſorium, nec ad tale ferrum convertitur: ſed ſtatim ut primum de candore aliquantulum remiſerit, confluit illico.*" In ſeveral other parts of his treatiſe he repeats the ſame thing with different circumſtances. It appears, therefore, that while iron is red hot, it is not ſuſceptible of magnetiſm, and that it is during the cooling in the magnetic direction that it acquires it. Gilbert endeavoured to mark the degree of heat moſt favourable for this purpoſe; but being unprovided with thermometers, he could not determine any thing with preciſion. He ſays, that the verſorium, or mariner's needle, was moſt deranged from its natural poſition a little while after the bar of iron ceaſed to ſhine in day-light, but was ſtill pretty bright in a dark room. But there are other experiments which we have made, and which will be mentioned by and bye; by which it appears, that although a bright red or a white heat makes iron unſuſceptible of magnetiſm while in that ſtate, it prediſpoſes it for becoming magnetical. When a bar of ſteel was made to acquire magnetiſm by tempering it in the magnetical direction, we found that the acquired magnetiſm was much ſtronger when the bar was made firſt of all very hot, even although allowed to come to its moſt magnetical ſtate before quenching, than if it had been heated only to that degree; nay, we always found it ſtronger when it was quenched when red hot. We offer no explanation at preſent; our ſole buſineſs juſt now being to ſtate facts, and to generalize them, in the hopes of finding ſome fact which ſhall contain all the others.

4. By juxtapoſition. 4. The moſt diſtinct acquiſitions and changes of magnetiſm are by juxtapoſition to other magnets and to iron. As the magnetiſm of a loadſtone or magnet is weakened by bringing its pole near the ſimilar pole of another magnet, it is improved by bringing it near the other pole; and it is always improved by bringing it near any piece of iron or ſoft ſteel.

But this action, and the mutual relation of magnets and common iron, being the moſt general, and the moſt curious and inſtructive of all the phenomena of magnetiſm, they merit a very particular conſideration.

Of the communication of Magnetiſm.

33 Communication of magnetiſm. The whole may be comprehended in one propoſition, which may be ſaid to contain a complete theory of magnetiſm.

Fundamental propoſition.

Any piece of iron, when in the neighbourhood of a magnet, is a magnet, and its polarity is ſo diſpoſed that the magnet and it mutually attract each other.

The phenomena which reſult from this fundamental principle are infinitely various, and we muſt content ourſelves with deſcribing a ſimple caſe or two, which will ſufficiently enable the reader to explain every other.

34 Attractive power communicated. Take a large and ſtrong magnet NAS (fig. 7.), of which N is the north, and S the ſouth pole. Let it be properly ſupported in a horizontal poſition, with its poles free, and at a diſtance from iron or other bodies. Take any ſmall piece of common iron, not exceeding two or three inches in length, ſuch as a ſmall key. Take alſo another piece of iron, ſuch as another ſmaller key, or a bit of wire about the thickneſs of an ordinary quill.

1. Hold the key horizontally, near one of the poles, (as ſhewn at n° 1.), taking care not to touch the pole with it; and then bring the other piece of iron to the other end of the key (it is indifferent which pole is thus approached with the key, and which end of the key is held near the pole). The wire will hang by the key, and will continue to hang by it, when we gradually withdraw the key horizontally from the magnet, till, at a certain diſtance, the wire will drop from the key, becauſe the magnetiſm imparted from this diſtance is too weak. That this is the ſole reaſon of its dropping, will appear by taking a ſhorter, or rather a ſlenderer, bit of wire, and touch the remote end of the key with it: it will be ſupported, even though we remove the key ſtill farther from the magnet.

2. Hold the key *below* one of the poles, as at n° 2. or 3. and touch its remote end with the wire. It will be ſuſpended in like manner, till we remove the key too far from the magnet.

3. Hold the key *above* the poles, as at n° 4. or 5. and touch its adjacent end with the wire (taking care that the wire do not alſo touch the magnet). The wire will ſtill be ſupported by the key, till both are removed too far from the magnet.

Thus it appears, that in all theſe ſituations the key has ſhewn the characteriſtic phenomenon of magnetiſm, namely, attraction for iron. In the experiment with the key held above the pole, the wire is in the ſame ſituation in reſpect to magnetiſm as the key is when held below the pole; but the actions are mutual. As the key attracts the wire, ſo the wire attracts the key.

If the magnet be ſupported in a vertical poſition, as in fig. 8. the phenomena will be the ſame; and when the key is held directly above or directly below the pole, it will carry rather a heavier wire than in the horizontal poſition of the magnet and key.

Inſtead of approaching the magnet with the key and wire, we may bring the magnet toward them, and the phenomena will be ſtill more palpable. Thus, if the bit of wire be lying on the table, and we touch one end of it with the key, they will ſhew no connection whatever. While we hold the key very near one end of the wire, bring down the pole of a magnet toward the key, and we ſhall then ſee the end of the wire riſe up and ſtick to the key, which will now ſupport it. In like manner, if we lay a quantity of iron filings on the table, and touch them with the key, in the abſence of the magnet, we find the key totally inactive. But, on bringing the magnet anyhow near the key, it immediately attracts the iron filings, and gathers up a heap of them.

35
Alſo a directive power.

In the next place, this vicinity of a magnet to a piece of iron gives it a directive power. Let NAS (fig. 9.) be a magnet, and BC (n° 1.) a key held near the north pole, and in the direction of the axis. Bring a very ſmall mariner's needle, ſupported on a ſharp point, near the end C of the key which is fartheſt from N. We ſhall ſee this needle immediately turn its ſouth pole towards C, and its north pole away from C. This poſition of the needle is indicated at *c*, by marking its north pole with a dart, and its ſouth with a croſs. Thus it appears that the key has got a directive power like a magnet, and that the end C is performing the office of a north pole, attracting the ſouth pole of the needle, and repelling its north pole. It may indeed be ſaid, that the needle at *c* arranges itſelf in this manner by the directive power of the magnet; for it would take the ſame poſition although the key were away. But if we place the needle at *b*, it will arrange itſelf as there repreſented, ſhewing that it is influenced by the key, and not (wholly at leaſt) by the magnet. In like manner, if we place the needle at *a*, we ſhall ſee it turn its north pole toward B, notwithſtanding the action of the magnet on it. This action evidently tends to turn its north pole quite another way; but it is influenced by B, and B is performing the office of a ſouth pole.

In like manner, if we place the key as at n° 2. we ſhall obſerve the end B attract the ſouth pole of the needle placed at *a*, and the end C attract the north pole of a needle placed in *b*. In this ſituation of the key, we ſee that B performs the office of a north pole, and C performs the office of a ſouth pole.

Thus it appears that the key in both ſituations has become a magnet, poſſeſſed of both an attractive and a directive power. It has acquired two poles.

36
The attraction of iron is owing to the diſpoſition of its own temporary magnetiſm.

Laſtly, the magnetiſm of the key is ſo diſpoſed, that the two magnets NAS and BC muſt mutually attract each other; for their diſſimilar poles front each other. Now, it is a matter of uniform and uncontradicted obſervation, that when a piece of iron is thus placed near a magnet, and the diſpoſition of its magnetiſm is thus examined by means of a mariner's needle, the diſpoſition is ſuch that two permanent magnets with their poles ſo diſpoſed muſt attract each other. The piece of iron, therefore, having the ſame magnetic relation to the magnet that a ſimilar and ſimilarly diſpoſed magnet has, muſt be affected in the ſame manner. We cannot, by any knowledge yet contained in this article, give any preciſe intimation in what way the polarity of the piece of iron will be diſpoſed. This depends on its ſhape as much as on its poſition. By deſcribing two or three examples, a notion is obviouſly enough ſuggeſted, which, although extremely gratuitous, and perhaps erroneous, is of ſervice, becauſe it has a general analogy with the obſerved appearances.

If one end of a ſlender rod or wire be held near the north pole of the magnet, while the rod is held in the direction of the axis (like the key in fig. 7. n° 1.), the near end becomes a ſouth, and the remote end a north pole. Keeping this ſouth pole in its place, and turning the rod in any direction from thence, as from a centre, the remote end is always a north pole. And, in general, the end of any oblong piece of iron which is neareſt to the pole of a magnet becomes a pole of the oppoſite name, while the remote end becomes a pole of the ſame name with that of the magnet.

If the iron rod be held perpendicularly to the axis, with its middle very near the north pole of the magnet, the two extremities of the iron become north poles, and the middle is a ſouth pole.

If the north pole of a magnet be held perpendicular to the centre of a round iron plate, and very near it, this plate will have a ſouth pole in its centre, and every part of its circumference will have the virtue of a north pole.

If the plate be ſhaped with points like a ſtar, each of theſe points will be a very diſtinct and vigorous north pole.

Something like this will be obſerved in a piece of iron of any irregular ſhape. The part immediately adjoining to the north pole of the magnet will have the virtue of a ſouth pole, and all the remote protuberances will be north poles.

The notion naturally ſuggeſted by theſe appearances is, that the virtue of a north pole ſeems to reſide in ſomething that is moveable, and that is protruded by the north pole of the magnet toward the remote parts of the iron; and is thus conſtipated in all the remote edges, points, and protuberances, much in the ſame manner as electricity is obſerved to be protruded to the remote parts and protuberances of a conducting body by the preſence of an overcharged body. This notion will greatly aſſiſt the imagination; and its conſequences very much reſemble what we obſerve.

As a farther mark of the complete communication of every magnetic power by mere vicinity to a magnet, we may here obſerve, that the wire D, of fig. 7. n° 2. and 3. will ſupport another wire, and this another; and ſo on, to a number depending on the ſtrength of the magnet. The key has therefore become a true magnet in every reſpect; for it induces complete magnetiſm on the appended wire. That this is not the ſame operation of the great magnet (at leaſt not wholly ſo), appears by examining the magnetiſm of D with the needle, which will be ſeen to be more influenced by D than by A. This fact has been long known. The ancients ſpeak of it: They obſerve, that a loadſtone cauſes an iron ring to carry another ring, and that a third; and ſo on, till the ſtring of rings appears like a chain.

37 Exception explained.

What has now been ſaid will explain a ſeeming exception to the univerſality of the propoſition. If the key be held in the ſituation and poſition repreſented by fig. 10. the bit of wire will not be attracted by it; and we may imagine that it has acquired no magnetiſm: But if we bring a mariner's needle, or a bit of wire, near to its remote end B, it will be ſtrongly attracted, and ſhew B to be a north pole. The needle held near to C will alſo ſhew C to be a ſouth pole. Alſo, if held near to D, it will ſhew D to be a north pole. Now the ends C, both of the key and of the wire, being ſouth poles, they cannot attract each other, but, on the contrary, they will repel; and therefore the wire will not adhere to the key. And if the key of fig. 17. nº 4. with the wire hanging to it, be gradually carried outward, beyond the north pole of the magnet, and then brought down till its lower end be level with the pole, the wire will drop off.

There is, however, one exception to the propoſition. If the key in fig. 7. with its appending wire D, be gradually carried from any of the ſituations 2, 3, 4, or 5, toward the middle of the magnet, the wire will drop off whenever it arrives very near the middle. If we ſuppoſe a plane to paſs through the magnetic centre A, perpendicular to the axis (which plane is very properly called the magnetic equatorial plane by Gilbert), a ſlender piece of iron, held anywhere in this plane, acquires no ſenſible magnetiſm. It gives no indication of any polarity, *and it is not attracted by the magnet*. It is well known, that the activity of a loadſtone or magnet reſides chiefly in two parts of it, which have been called its poles; and that thoſe are the beſt magnets or loadſtones in which this activity is leaſt diffuſed; and that a certain circumference of every loadſtone or magnet is wholly inactive. When a loadſtone or magnet of any ſhape is laid among iron filings, it collects them on two parts only of its ſurface, and between theſe there is a ſpace all round, to which no filings attach themſelves.

We preſume that the reader already explains this appearance to himſelf. Many things ſhew a contrariety of action of the two poles of a magnet. We have already obſerved, that the north pole of a ſtrong magnet will produce a ſtrong northern polarity in the remote end of a ſmall ſteel bar; and, if it be then applied near to that end in the oppoſite direction, it will deſtroy this polarity, and produce a ſouthern polarity. In whatever theſe actions may conſiſt, there is ſomething not only different but oppoſite. They do not blend their effects, as the yellow and blue making rays do in producing green. They oppoſe each other, like mechanical preſſures or impulſions. We have every mark of mechanical action; we have local motion, though unſeen, except in the gradual progreſſion of the magnetical faculties along the bar; but we have it diſtinctly in the ultimate effect, the approach or receſs of the magnets: and in theſe phenomena we ſee plainly, that the forces, in producing their effects, act in oppoſite directions. Whatever the internal inviſible motions may be, they are compoſed of motions whoſe equivalents are the ſame with the equivalents of the ultimate, external, ſenſible motions; therefore the internal motions are oppoſite and equal if the ſenſible motions are ſo, and converſely.

Adopting this principle, therefore, that the actions of the two poles are not only different but oppoſite, it follows, that if they are alſo equal and act ſimilarly, each muſt *prevent* the action of the other; and that there will be a mechanical equilibrium—it may even be called a magnetical equilibrium. Therefore if every part of a ſlender rod, or of a thin plate of iron, lie in the plane of the magnetic equator, the magnetic ſtate (in whatever it may conſiſt) cannot be produced in it. It will exhibit no magnetiſm; have no polar faculties; and we can ſee no reaſon why it ſhould be attracted by the magnet, or ſhould attract iron. We muſt not forget to obſerve in this place, that iron in a ſtate of incandeſcence acquires no magnetiſm by juxtapoſition. We have already remarked, that iron in this ſtate does not affect the magnet. If a bar of red hot iron be ſet near a mariner's needle, it does not affect it in the ſmalleſt degree till it almoſt ceaſes to appear red hot in day-light, as has been obſerved by Dr Gilbert. All actions that we know are accompanied by equal and oppoſite re-actions; and we ſhould expect, what really happens in the preſent caſe, namely, that red hot iron ſhould not be rendered magnetical and attractable.

38 Magnetiſm not impaired by communication.

There is a very remarkable circumſtance which accompanies the whole of this communication of magnetiſm to a piece of iron. It does not impair the power of the magnet; but, on the contrary, improves it. This fact was obſerved, and particularly attended to, by Dr Gilbert. He remarks, that a magnet, in the hands of a judicious philoſopher, may be made to impart more magnetiſm than it poſſeſſes to each of ten thouſand bars of ſteel, and that it will be more vigorous than when the operations began. A magnet (ſays he) may be ſpoiled by injudicious treatment with other magnets, but never can touch a piece of common iron without being improved by it. He gives a more direct proof. Let a magnet carry as heavy a lump of iron as poſſible by its lower pole. Bring a great lump of iron cloſe to its upper pole, and it will now carry more. Let it be loaded with as much as it can carry while the lump of iron touches its upper pole. Remove this lump, and the load will inſtantly drop off. But the following experiment ſhews this truth in the moſt convincing manner:

Let NAS (fig. 11.) be a magnet, not very large, nor of extreme hardneſs. Let CD be a ſtrong iron wire, hanging perpendicularly from a hook by a ſhort thread or loop. The magnet, by its action on CD, renders D a north pole and C a ſouth pole, and the polarity of D's magnetiſm fits it for being attracted. Let it aſſume the poſition C*e*, and let this be very carefully marked. Now bring a great bar of iron *s* B *n* near to the other end of the magnet. We ſhall inſtantly perceive the wire C*e* approach to the ſouth pole of the magnet, taking a poſition C*f*. Withdraw the bar of iron, and C*f* will fall back into the poſition C*e*. As we bring the iron bar gradually nearer to the magnet, the wire will deviate farther from the perpendicular, and when the bar B touches the magnet CD, will ſtart a great way forward. It is alſo farther to be obſerved, that the larger the bar of iron is, the more will CD deviate from the perpendicular.

Now this muſt be aſcribed to the action of the bar on the magnet. For if the magnet be removed, the bar alone will make no ſenſible change on the poſition of the wire. We know that the bar of iron becomes magnetical by the vicinity of the magnet. If we doubt this, we need only examine it by means of a piece of iron or a mariner's needle. This will ſhew us that *s* has become a ſouth, and *n* a north pole. Here then are two magnets with their diſſimilar poles fronting each other. In conformity with the whole train of magnetical phenomena, we muſt conclude that they attract each other, and muſt improve each other's magnetiſm.

39 Therefore nothing is tranſferred.

This is a moſt important circumſtance in the theory of magnetiſm. For it ſhews us, that, in rendering a piece of iron magnetic, there is no material communication. There is no indication of the transference of any ſubſtance reſiding in the magnet into the piece of iron; nor is there even any transference of a power or quality. Were this the caſe, or if the ſubſtance or quality which was in A be now tranſferred to B, it can no longer be in A; and therefore the phenomena reſulting from its preſence and agency muſt be diminiſhed. We muſt ſay that the magnet has excited powers inherent, but dormant, in the iron; or is, at leaſt, the occaſion of this excitement, by diſturbing, in ſome adequate manner, the primitive condition of the iron. We muſt alſo ſay, that the competency of the magnet and of the iron to produce the phenomena, is owing to the ſame circumſtances in both; becauſe we ſee nothing in the phenomena which authoriſes us to make any diſtinction between them. Whatever therefore cauſes one magnet to attract another, is alſo the reaſon why a piece of iron in the neighbourhood of a magnet attracts another piece of iron; and we muſt ſay that the cauſe of polarity, or the origin of the directive power, is the ſame in both. Now we underſtand perfectly the directive power of a magnet, as exerted on another magnet. We ſee that it ariſes from a combination and mechanical compoſition of attractions and repulſions. It muſt be the ſame in this magnetiſm now inherent in the iron. The piece of iron directs a mariner's needle, as a magnet would direct it; therefore, as there is ſomething in a piece of iron which *now* attracts ſomething in another piece of iron, ſo there is ſomething in the firſt which repels ſomething in the laſt.

40 Objections anſwered by a curious fact.

It may indeed be ſaid that it is not a piece of iron, but a mariner's needle, or magnet, that is thus directed by our iron magnetiſed by vicinity to a magnet. This objection is completely removed by the moſt curious of all the facts which occur in this manner of producing magnetiſm. Take a piece of common iron, faſhion it, and fit it up preciſely like a mariner's needle, and carefully avoid every treatment that can make it magnetical. Set it on its pivot, and bring it near the north pole of a magnet, placing the end, made like the ſouth pole of the needle, next to the north pole of the magnet. In ſhort, place it by hand exactly as a real mariner's needle would arrange itſelf. It will retain that poſition. Now carry it round the magnet, along the circumference of a magnetic curve, or in any regular and continuous route. This piece of iron will, in every ſituation, aſſume the very ſame poſition or attitude which the real magnetical needle would aſſume if in the ſame place, and it will oſcillate preciſely in the ſame way.

Here then it is plain, that there is no diſtinction of power between the magnetiſm of the iron and of the real needle. To complete the proof: Inſtead of approaching the magnet with this iron needle, bring it into the vicinity of a piece of iron, which is itſelf magnetical only by vicinity to a magnet, it will arrange itſelf juſt as the real needle would do, with the ſole difference, that it does not indicate the *kind* of polarity exiſting in the extremities of the iron, becauſe either end of it will be attracted by them. And this circumſtance leads us to the conſideration of the only diſtinction between the magnetiſm of a loadſtone or magnet and that of common iron.

41 Magnetiſm of iron is tranſitory and indifferent; but that of magnets is durable and determinate.

The magnetiſm of common iron is momentary, and therefore indifferent; whereas that of a magnet is permanent and determinate. When iron becomes magnetic in the way now mentioned, it remains ſo only while the magnet remains in its place; and when that is removed, the iron exhibits no ſigns of magnetiſm. Therefore when the north pole of a magnet has produced a ſouth pole in the neareſt end of an iron wire, and a north pole at its remote end, if we turn the magnet, and preſent its ſouth pole, the neareſt end of the wire inſtantly becomes a north pole, and the other a ſouth pole; and this change may be made as often, and as rapidly, as we pleaſe. This is the reaſon which made us direct the experimenter on the iron needle to begin his operation, by placing the end marked for a ſouth pole next to the north pole of the magnet. It becomes a real ſouth pole in an inſtant, and acts as ſuch during its peregrination round the magnet. But in any one of its ſituations, if we turn it half round with the finger, the end which formerly turned away from a pole of the magnet, will now turn as vigorouſly toward it. Therefore, in carrying the iron needle round the magnet, we directed the progreſs to be made in a continuous line, to avoid all chance of miſtaking the polarities.

42 Magnetiſm of Induction.

For all the reaſons now adduced, we think ourſelves obliged to ſay, that the magnetiſm produced on common iron by mere juxtapoſition to a magnet, is generated without any *communication* of ſubſtance or faculty. The power of producing magnetical phenomena is not *ſhared* between the magnet and the iron. We ſhall call it INDUCED MAGNETISM; MAGNETISM BY INDUCTION.

We have ſaid that induced magnetiſm of common iron is quite momentary. This muſt be underſtood with careful limitations. It is ſtrictly true only in the caſe of the fineſt and pureſt ſoft iron, free of all knots and hard veins, and therefore in its moſt metallic ſtate. Iron is rarely found in a ſtate ſo very pure and metallic; and even this iron will acquire permanent and determinate magnetiſm by induction, if it has been twiſted or hammered violently, although not in the magnetic direction; alſo the changes produced (we imagine) on the pureſt iron by the action of the atmoſphere make it ſuſceptible of fixed magnetiſm. But the magnetiſm thus inducible on good iron is ſcarcely ſenſible, and of no duration, unleſs it has lain in the neighbourhood of a magnet for a very long while.

What has now been ſaid of common iron, is alſo true of it when in the ſtate of ſoft ſteel.

43 Tempered ſteel acquires durable magnetiſm.

But any degree of temper that is given to ſteel makes a very important change in this reſpect. In the firſt place, it acquires magnetiſm more ſlowly by induction than an equal and ſimilar piece of common iron, and finally acquires leſs. Theſe differences are eaſily examined by the deviations which it cauſes in the mariner's needle from the magnetic meridian, and by its attraction.

When the inducing magnet is removed, ſome magnetiſm remains in the ſteel bar, which retains the polarity which it had in the neighbourhood of the magnet.

Steel tempered to the degree fit for watch ſprings acquires a ſtrong magnetiſm, which it exhibits immediately on the removal of the magnet. But it diſſipates very faſt; and, in a very few minutes, it is reduced to leſs than one-half of its intenſity while in contact with the magnet, and not two-thirds of what it was immediately on removal from it. It continues to diſſipate for ſome days, though the bar be kept with care; but the diſſipation diminiſhes faſt, and it retains at leaſt one-third of its greateſt power for any length of time, unleſs careleſsly kept or injudiciouſly treated.

Steel tempered for ſtrong cutting tools, ſuch as chiſels, punches, and drills for metal, acquires magnetiſm ſtill more ſlowly by induction, and acquires leſs of it while in contact with the magnet; but it retains it more firmly, and finally retains a greater proportion of what it had acquired.

Steel made as hard as poſſible, is much longer in acquiring all the magnetiſm which ſimple juxtapoſition can give to it. It acquires leſs than the former; but it retains it with great firmneſs, and finally retains a much greater proportion.

Such ores of iron as are ſuſceptible of magnetiſm, are nearly like hard ſteel in theſe reſpects; that is, in the time neceſſary for their *greateſt* impregnation, and in the durability of the acquired magnetiſm. They differ exceedingly in reſpect to the degree of power which they can attain by mere juxtapoſition, and the varieties ſeem to depend on heterogeneous mixture. We muſt obſerve, that few ores of iron are ſuſceptible of magnetiſm in their natural ſtate. The ordinary ores, conſiſting of the metal in the ſtate of an oxyd, and combined with ſulphur, are not magnetizable while remaining in that ſtate. Moſt ores require roaſting, and a ſort of cementation, in contact with inflammable ſubſtances. This matter is not well underſtood; but it would ſeem that complete metallization is far from being the moſt favourable condition, and that a certain degree of oxydation, and perhaps ſome other compoſition, yet unknown, make the beſt loadſtones. But all this is extremely obſcure. The late Dr Gowin Knight made a compoſition which acquired a very ſtrong and permanent magnetiſm, but the ſecret died with him. Dr Gilbert ſpeaks of ſimilar compoſitions, in which ferrugineous clays were ingredients; but we know nothing of the ſtate of the metal in them, nor their mode of acquiring magnetiſm.

44 Induction of magnetiſm is gradual and progreſſive.

It is of peculiar importance to remark that the acquiſition of magnetiſm is gradual and progreſſive, and that the gradation is the more perceptible in proportion as the ſteel is of a harder temper. When a magnet is brought to one end of a bar of common iron, its remote extremity, unleſs exceedingly long, acquires its utmoſt magnetiſm immediately. But when the north pole of a magnet is applied to one end of a bar of hard ſteel, the part in contact immediately becomes a ſouth pole, and the far end is not yet affected. We obſerve a north pole formed at ſome diſtance from the contact, and beyond this a faint ſouth pole. Theſe gradually advance along the bar. The remote extremity becomes firſt a faint ſouth pole, and it is not till after a very long while (if ever) that it becomes a ſimple, vigorous, north pole. More frequently it remains a diffuſed and feeble north pole: nay, if the bar be very long, it often happens that we have a ſucceſſion of north and ſouth poles, which never make their way to the far end of the bar. This phenomenon was firſt obſerved (we think) by Dr Brook Taylor, who gives an account of his obſervations in the *Philoſophical Tranſactions*, n° 344.

45 Iron is attracted only becauſe it becomes magnetical.

From the account we have given of theſe phenomena of induced magnetiſm, it appears that the temporary magnetiſm is always ſo diſpoſed that the ſum of the mutual attractions of the diſſimilar poles exceeds the ſum of the repulſions between the ſimilar poles, and that therefore the two magnets tend to each other. This is evidently equivalent to ſaying, that a piece of unmagnetic iron is always attracted by a magnet. No exception has ever been obſerved to this fact; for Pliny's ſtory of a Theamedes, or loadſtone, which repels iron, is allowed by all to have been a fable.

We think ourſelves authoriſed to ſay that this attraction of the loadſtone for iron, or this tendency of iron to the loadſtone, is a ſecondary phenomenon, and is the *conſequence* of the proper diſpoſition of the induced magnetiſm. The proofs already given of the compound nature of this phenomenon, namely, that it ariſes from the exceſs of two attractions above two repulſions, need (we imagine) no addition. But the following conſiderations place the matter beyond doubt:

1. The magnetiſm of the two poles is evidently of an oppoſite nature; the one repelling what the other attracts. If the one attracts iron, therefore, the other ſhould repel it. But each pole, by inducing a magnetiſm oppoſite to its own, on the neareſt end of the iron, and the ſame with its own on the remote end, and its action diminiſhing with an increaſe of diſtance, there muſt always be an exceſs of attraction, and the iron muſt be attracted.

2. Each of the magnets A and B, in either of the poſitions repreſented in fig. 13. would alone attract the piece of common iron C. But when placed together, the ſouth pole of A tends to render the upper end of C a north pole; while the north pole of B tends to make it a ſouth pole. If their actions be nearly equal, the weight of C cannot be ſupported by the magnetiſm induced by any difference of action that may remain. While C is hanging by B alone, let A be gradually brought near; it gradually deſtroys the action of the north pole of B, ſo that C gradually loſes its magnetiſm and polarity, and its weight prevails.

3. In all thoſe caſes where the induction of magnetiſm is ſlow, the attraction is weak in proportion. This is particularly remarked by Dr Gilbert. If we take pieces of common iron, and of ſteel of different tempers, but all of the ſame ſize and form, we ſhall find that the iron is much more ſtrongly attracted than any of the reſt, and that the attraction for each of them is weaker in proportion as they are harder. This diverſity is ſo accurately obſerved, that when the piece is thoroughly

ſuſceptible of magnetiſm, we can tell, with conſiderable preciſion, what degree will be ultimately acquired, and how much will be finally retained. Alſo, the attraction of the magnet for any of thoſe pieces of ſteel increaſes exactly in proportion as their acquired magnetiſm increaſes.

4. An ore of iron incapable of acquiring magnetiſm is not attracted by a magnet. But we know that, by cementation with charcoal duſt, they may be rendered ſuſceptible of magnetiſm. In this ſtate they are attracted. It is an univerſal fact, that any ſubſtance that is attracted by a magnet may be rendered magnetical, and that none elſe can. We have already obſerved that red hot iron is not attracted; nor does it acquire any directive power while in that ſtate. From all this we muſt conclude, that the previous induction of magnetiſm is the mean of the obſerved attraction of magnets for iron, and that this is not a primary fact in magnetiſm.

Theſe obſervations alſo complete the proof that magnetic attraction and repulſion are equal at the ſame diſtance, and follow the ſame law. Dr Gilbert ſeems to think, that the repulſion is always weaker than the attraction; and this is almoſt the only miſtake in conception into which that excellent philoſopher has fallen. But it only requires a fair compariſon of facts to convince a good logician, that ſince, *in every caſe*, and at every diſtance, either pole of a magnet attracts either end of a piece of common iron, it is impoſſible that one of theſe forces can exceed the other. It might be ſo, were it not that induced magnetiſm is durable in proper ſubſtances. And if we take magnets which have been made ſuch by induction, and preſent them to each other with their ſimilar poles fronting each other, they never fail to repel each other at conſiderable diſtances, and even at very ſmall diſtances for a few moments; and this is the caſe whichever poles are next each other. This cannot be on any other ſuppoſition. Caſes would occur of polarity without attraction, or of attraction without polarity. Such have never been ſeen, any more than the Theamedes, always repelling iron.

46 Phenomena of iron ſhreds and filings.

Let a great number of ſmall oblong pieces of iron be lying very near each other on the ſurface of quickſilver. Bring a ſtrong magnet into the midſt of them. It immediately renders them all magnetical by induction. The one neareſt the north pole of the magnet immediately turns one end toward it, and the other end away from it. The ſame effect is produced on the one that is juſt beyond this neareſt one. Thus the remote end of the firſt becomes a north pole, and the neareſt end of the ſecond becomes a ſouth pole. Theſe, being very near each other, muſt mutually attract. The ſame thing may be ſaid of a third, a fourth; and ſo on. And thus it appears, that not only is magnetiſm induced on them all, but alſo, that the magnetiſm of each is ſo diſpoſed, that both ends of it are in a ſtate of attraction for the ends of ſome of its neighbours; and that they will therefore arrange themſelves by coaleſcence in ſome particular manner. Should a parcel of them chance to be ſtanding with their centres in a magnetic curve, with their heads and points turned in any ways whatever, the moment that the magnet is brought among them, and ſet in the axis of that magnetic curve, the whole pieces of this row will inſtantly turn towards each other, and their ends will adhere together, if they are near enough; otherwiſe they will only point toward each other, forming a ſet of tangents to the magnetic curve, reaching from one pole of the magnet to the other.

Or, ſuppoſe a vaſt number of ſmall bits of iron, each ſhaped like a grain of barley, a little oblong. Let them be ſcattered over the ſurface of a table, ſo near each other as juſt to have room to turn round. Let a magnet be placed in the midſt of them. They will all have magnetiſm induced on them in an inſtant; and ſuch as are not already touching others, will turn round (becauſe they reſt on the table by one point only), and each will turn its ends to the ends of its neighbours; and thus they will arrange themſelves in curves, which will not differ greatly from true magnetic curves (becauſe each grain is very ſhort), iſſuing from one pole of the magnet, and terminating in the other.

Does not this ſuggeſt to the reflecting reader an explanation of that curious arrangement of iron filings round a magnet, which has ſo long entertained and puzzled both the philoſophers and the unlearned, and which has given riſe to the Carteſian and other theories of magnetiſm? The particles of iron filings are little rags of ſoft iron torn off by the file, and generally a little oblong. Theſe *muſt* have magnetiſm induced on them by a magnet, and, while falling through the air from the hand that ſtrews them about the magnet, they are at perfect liberty to arrange themſelves magnetically; and *muſt therefore ſo arrange themſelves*, forming on the table curves, which differ very little indeed from the true magnetic curves. Suppoſe them ſcattered about the table before the magnet is laid on it. If we pat the table a little, ſo as to throw it into tremors, this will allow the particles to dance, and turn round on their points of ſupport, till they coaleſce by their ends in the manner already deſcribed.

All this is the genuine and inevitable conſequence of what Dr Gilbert has taught us of induced magnetiſm. It muſt be ſo; and cannot be otherwiſe. This curious arrangement of iron filings round a magnet is therefore not a primary fact, and a foundation for a theory, but the reſult of principles much more general.

47 Remarks on the theories by impulſion.

Moſt of our readers know that this diſpoſition of iron filings has given riſe to the chief mechanical theories which have been propoſed by ingenious men for the explanation of all the phenomena of magnetiſm. An inviſible fluid has been ſuppoſed to circulate through the pores of a magnet, running along its axis, iſſuing from one pole, ſtreaming round the magnet, and entering again by the other pole. This is thought to be indicated by thoſe lines formed by the filings. The ſtream, running alſo through *them*, or around them, arranges them in the direction of its motion, juſt as we obſerve a ſtream of water arrange the flote graſs and weeds. It would require a volume to detail the different manners in which thoſe mechanicians attempt to account for the attraction, repulſion, and polarity of magnetic bodies, by the mechanical impulſion of this fluid. Let it ſuffice to ſay, that almoſt every ſtep of their theories is in contradiction to the acknowledged laws of impulſion. Nay, the whole attempt is againſt the firſt rule of all philoſophical diſcuſſion, never to admit for an explanation of phenomena the agency of any cauſe which we do not know to exiſt, and to operate in the very phenomenon. We know of no ſuch fluid; and we can demonſtrate, that the genuine effects of its impulſion would be totally unlike the phenomena

nomena of magnetiſm. But the proper refutation of theſe theories would fill volumes. Let it ſuffice (and to every logician it will abundantly ſuffice) to remark, that this phenomenon is but a ſecondary fact, depending on, and reſulting from, principles much more general, viz. the induction of magnetiſm, and the attraction of diſſimilar, and repulſion of ſimilar, poles.

The above explanation of the curious diſpoſition of iron filings round a magnet, occurred to the writer of this article while ſtudying natural philoſophy, on ſeeing the Profeſſor exhibit Mr Henſhaw's beautiful experiment in proof of terreſtrial magnetiſm *. He at that time imagined himſelf the author, and promiſed himſelf ſome credit for the thought. But having ſeen the *Phyſiologia Nova de Magnete* by Dr Gilbert, he found that it had not eſcaped the notice of that ſagacious philoſopher; as will appear paſt diſpute from the following paſſage, as well as ſome others, leſs pointed, in that work: "Magnetica fruſta (that is, ſubſtances ſuſceptible of magnetiſm) bene et convenienter intra vires poſita, mutuo cohærent. Ferramenta, preſente magnete (etiamſi magnetem non attingant), concurrunt, ſolicité ſe mutuo quærunt, et amplexantur, et, conjuncta, quaſi ferruminantur. Scobs ferrea, vel in pulverem redacta, fiſtulis impoſita chartaceis—ſupra lapidem meridionaliter locata, vel propius tantum admota, in unum coaleſcet corpus; et ſubito tam multæ partes concreſcunt et combinantur; ferrumque aliud affectat conjuratorum turma et attrahit, ac ſi unum tantum et integrum eſſet ferri bacillum; dirigiturque ſupra lapidem in ſeptemtriones et meridiem. Sed cum longius a magnete removeantur (tanquam ſoluta rurſus) ſeparantur, et diffluunt ſingula corpuſcula." B. ii. c. 23.

* See Variation, *Encycl.* p. 621.

Mr Æpinus alſo had taken the ſame view of the ſubject *. It is alſo very clearly conceived and expreſſed by the celebrated David Gregory, Savilian Profeſſor of aſtronomy in the Univerſity of Oxford, in a MS. volume of notes and commentaries, written by him in 1693, on Newton's *Principia*, and uſed by Newton in improving the ſecond edition. The M. S. is now in the library of the univerſity of Edinburgh. Gregory's words are as follow: "Mihi ſemper dubium viſum eſt num magnetica virtus mechanicé, *i. e.* per impulſum, producatur. Mirum eſt, effluvia, quæ ferrum agitare valent, bracteas aureas *interpoſitas* ne vel minimum a loco movere. Lucretii et Carteſii theoriam, de fugato intermedio aëre, refutat experimentum infra aquam inſtitutum. *Sulci in limatura ferri, magneti in plano cujuſvis meridiani circumpoſita, non fiunt ab effluviis ſecundum iſtos canales motis, ſed ex inde, quod ipſu ramenta, magnetice excitata, ſeſe ſecundum longitudinem et ſecundum polos diſponunt.* Ex altera vero parte exinde quod vis magnetica, interveniente flamma aut calore, interrumpatur, quod virga ferrea, vel diuturno ſitu perpendiculari, vel in eo ſitu frigeſcendo, virtutem magneticam a tellure acquirat, ut nos docet perſpicaciſſimus Gilbertus. Quod mallei ſuper incudem ictu forti ad alterum extremum, virtutem acquirat magneticam; quod ictu forti vel ſaltem fortiori ad alterum extremum poli permutantur, ut qui prius ſeptemtriones reſpiciebat nunc auſtrum reſpicit; quod ictu forti ad medium, virtutem illam prorſus amittat. Hæc inquam, et ſimilia, mechanicam ejus qualitates ortum arguunt. Hugenius, præter gravitatem, etiam magneticam, et electricam virtutem, aliaſque plures experimento novit vires naturales, ut mihi ipſi narravit hac eſtate anni 1693. Qualis ut hæc forſitan quod cymba papyracea, prope labra vaſis aquam, cui innatet, continentis, poſita, labrum viciniſſimum continuo, et cum impetu petat (A)." *Nat. MS. in Prop.* 23. ii. *Prin.*

* See § 306.

48 Filings are weakly attracted.

Not only the mere arrangement of the filings in curve lines follows of neceſſity from the properties of induced magnetiſm, but all the ſubordinate circumſtances of this phenomenon are included in the ſame explanation. By continuing to tap the table, and throw it into tremors, the filings are obſerved to approach gradually, but very ſlowly, to the poles of the magnet. Each particle is a very ſmall temporary magnet. The attractive power of the great magnet, $\overline{m-p}-\overline{n-q}$, is therefore extremely ſmall in proportion to its directive power, $\overline{m+p}-\overline{n+q}$. And we obſerve that the accumulation of the filings round the poles of the magnet is ſo much the ſlower as the filings are finer.

49 Curious fact.

If a paper be laid above the magnet, and the filings be ſprinkled on it, we obſerve them to conſtipate along its edges, while none remain immediately above its ſubſtance; they are all beyond, or on the outſide of its outline, and they are obſerved not to be lying flat on the paper, but to be ſtanding obliquely on one point. They move off from the paper immediately above the magnet, becauſe they repel each other. They ſtand obliquely from the edges, becauſe that is the direction of a magnetic meridian at its parting from the pole. If the magnet be at ſome diſtance below the paper, then tapping the paper will cauſe the filings to move away from the magnet laterally. This ſingular and unexpected appearance is owing to the combination of gravity with the magnetic action. A particle, ſuch as *n s* (fig. 13.), reſts on the paper by the point *n*, which is a temporary north pole (S being ſuppoſed the ſouth pole of the magnet). The particle takes a poſition *n s* nearer to the horizon than the poſition *n o*, which it would take if its centre of gravity *b* were ſupported. The poſition is ſuch, that its weight, acting vertically at *b*, is in equilibrio with the magnetic repulſion *s d*, exerted between S and *s*. When the paper is tapped, it is beaten down, or withdrawn from *n*, and the particle of iron is left for a moment in the air. It therefore turns quickly round *b*, in order to aſſume a poſition parallel to *n o*, and it meets the paper, as that riſes again after the ſtroke, in a point farther removed from the magnet, and again deſcends by its weight (turning round the newly ſupported point *n*), till it again takes a poſition parallel to *n s*, but farther off, as repreſented by the dotted line. Thus it travels gradually outwards from the magnet; appearing to be repelled, although it is really attracted by it. If the magnet be held above the paper, at a little diſtance, the filings, when we repeatedly pat the paper, gradually collect into a heap under it. This will appear very plainly to one who conſiders the ſituation of a particle in the manner now explained.

(A) Perhaps it may be proper to obſerve, that Dr Gregory expreſſes his differing in his opinion from Newton about magnetiſm. Newton, in this propoſition, thinks, that the law of magnetic action approaches to the inverſe triplicate ratio of the diſtances. Dr Gregory invalidates the argument uſed by Newton.

50 Filings arrange in magnetic curves.

The curve lines formed by very fine filings approach very nearly to the form of the primary curve which indicates the law of magnetic action in the way already explained. If the magnet be placed under water, and if filings be ſprinkled copiouſly on the ſurface of it from a gauze ſearce, held at ſome diſtance above it, the reſiſtance to their motion through the water gives them time to arrange themſelves magnetically before they reach the bottom, and the lines become more accurate. But they were ſo much deranged by any method that we could take for removing the water, and meaſuring them, that we were diſappointed in our expectations of obtaining a very near approximation to the law of action.

51 Alſo in ſecondary curves.

We took notice of ſome very ſingular phenomena of a compaſs needle in the neighbourhood of two magnets, and we obſerved that, in this caſe alſo, the needle was always a tangent to a curve of another kind, and which we called *ſecondary* and *compound magnetic curves.* Theſe are produced in the ſame way, by ſtrewing iron filings round the magnets. Many repreſentations have been given of theſe curves by different authors, particularly by Muſchenbroeck, in his *Eſſais de Phyſique*; and by Fuſs in the *Comment. Petropolit.* Great uſe has been made of theſe arrangements of filings by two magnets in the theories of magnetiſm propoſed by thoſe who inſiſt on explaining all motion by impulſe. When the diſſimilar poles of two magnets A and B (fig. 14.) face each other, the curves formed by the filings conſiderably reſemble thoſe which ſurround a ſingle magnet, and give the whole ſomewhat of the appearance of a magnet with very diffuſed poles. The arranging fluid, which ſtreams from one pole of a magnet, is ſuppoſed to meet with no obſtruction to its entry into the adjoining pole of the other magnet, but, on the contrary, to be impelled into it; and therefore (ſay the propoſers) it circulates round both as one magnet, and by its vortex brings the magnets together; which phenomenon we call the attraction of the magnets. But when the ſimilar poles front each other; for example, the poles from which the arranging fluid iſſues, then the two ſtreams meet, obſtruct each other, accumulate, and, by this accumulation, cauſe the magnets to recede from each other; which we call the repulſion of the magnets. This is the only explanation of this kind that can make any pretenſions to probability, or indeed that can be conceived. For how the free circulation in the former caſe can bring the two magnets together, no perſon can form to himſelf any conception. We ſee nothing like this produced by any vortex that we are acquainted with. All ſuch vortices cauſe bodies to ſeparate. But even this explanation of magnetic repulſion is inadmiſſible. It will not apply to the repulſion of the receiving poles; and the phenomena of the filings are inconſiſtent with the notion of accumulation. The filings indeed accumulate, and they look not unlike two ſtreams which oppoſe each other, and deflect to the ſides (See fig. 15.): But, unfortunately, by tapping the paper gently, the filings do not move off from the magnets, but approach them much faſter than in any other experiment. The phenomenon receives a complete and palpable explanation from the principles we have eſtabliſhed. Both magnets concur in giving the ſame polarity to every particle of the filings. Thus, if the fronting poles are north poles, each particle has its neareſt end made a vigorous ſouth pole, and its remote end a north pole; and it is *therefore* ſtrongly attracted towards both magnets while it is arranged in the tangent to the ſecondary curve of that claſs, which croſſes the others nearly at right angles.

52 Magnets muſt affect each other.

Since it is found, that the magnetiſm, even of natural loadſtones and hard ſteel, and ſtill more thoſe of ſofter tempered ſteel, are continually tending to decay; and ſince we find that it may be induced by mere approach to a magnet; and ſince we know that magnets may oppoſe each other in producing it—it is reaſonable to ſuppoſe, that when a piece of iron has acquired a ſlight, though permanent magnetiſm, by the vicinity of a magnet, a magnet applied in the oppoſite direction will deſtroy it, and afterwards produce the oppoſite magnetiſm.

Accordingly, we may change the poles of ſoft magnets at pleaſure.

Farther; ſince we find that loadſtones and hard tempered ſteel bars are diſtinguiſhed from ſoft ones only by the *degree* of obſtinacy with which they retain their preſent condition, we ſhould alſo expect that hard magnets will even affect each other. It muſt therefore happen, that a powerful magnet applied to a weak one, ſo that their ſimilar poles are in contact, ſhall weaken, deſtroy, and even change the magnetiſm of the weaker. Dr Knight's famous magazine of magnets enabled him to change the poles of the greateſt and the ſtrongeſt natural loadſtone, or artificial magnet, that could be given him, in the ſpace of one minute.

53 Attraction muſt appear to exceed repulſion.

We now ſee clearly the reaſon why magnetic repulſion is weaker than attraction at the ſame diſtance. When magnets are placed with their ſimilar poles fronting each other, in order to make trials of their repulſion, they really do weaken each other, and are not in the ſame magnetical condition as before. For ſimilar reaſons, we ſee how experiments with magnets attracting each other rather improve them, and make their attractive powers appear greater than they are. All theſe effects muſt be moſt remarkable in ſoft magnets, eſpecially when long.

54 The obſerved law differs from the true.

We alſo ſee, that the obſerved law of attraction and repulſion between two magnets muſt be different from the real law of magnetic action. For, in the experiments made on attraction at different diſtances, beginning with the greateſt diſtance, the magnetiſm is continually increaſing, and the attraction will appear to increaſe in a higher rate than the juſt one: the contrary may happen, if we begin with the ſmaller diſtances. The reſults of experiments on repulſion muſt be ſtill more erroneous; becauſe it is eaſier to diminiſh any accumulation which required an exertion to produce it, than to puſh it ſtill farther.

55 Magnetiſm improves by inducing it on iron.

We have now a complete explanation of the remarkable fact, that the induction of magnetiſm does not weaken the magnet employed; but, on the contrary, improves it. The magnetiſm induced on the iron cauſes it to act on the magnet employed in the very ſame manner that a permanent magnet of the ſame ſhape, ſize, and ſtrength, would do. Nay, it will have even a greater effect; for as it improves the magnet, its own induced magnetiſm will improve; and will therefore ſtill farther improve the magnet.

56.

Hence it is, that, in whatever manner a magnet touches a piece of iron, it improves by it. It may be hurt by a magnet in an improper poſition; but it always puts common iron into a ſtate which increaſes its own magnetiſm. This has been known as long as magnetiſm itſelf; and the ancients conceived the notion, that the magnet ſomehow fed upon the iron (B).

We think that theſe obſervations authoriſe us to ſay, that in reducing a loadſtone into a convenient ſhape, as much as poſſible of the operation ſhould be performed by grinding them with emery, in cavities made in large blocks of *hammered* iron. The magnetiſm induced on the iron muſt be favourable to the conſervation of that in the loadſtone; which, we are perſuaded, is rapidly diſſipated by the tremors into which this very elaſtic ſubſtance is thrown by the grinding with coarſe powders in any mould but iron. We imagine, that the cutting off ſlices by the lapidaries wheel has the ſame bad effect.

57. Not only will a magnet lift a greater lump of iron by its north pole, when another lump is applied to its ſouth pole, but it will lift a greater piece of iron from an anvil than from a wooden table: for the magnet induces the properly diſpoſed polarity, not only in the iron which it lifts, but alſo in the anvil, or any piece of iron immediately beyond it. This is ſo diſpoſed as to increaſe the magnetiſm of the piece of iron between them; and therefore to increaſe their attraction. The magnetiſm induced on the anvil is alſo in part, and perhaps chiefly, induced by the intervening iron. Theſe experiments are extremely variable in their reſults.—Sometimes a ſmall magnet will pull an iron wire from a large and ſtrong one. Sometimes this will be done even by a piece of unmagnetic iron; and the reſults appear quite capricious. But they are accurately fixed, depending on the induced compound magnetiſm. Mr Æpinus has ſtated ſome of the more ſimple caſes, in which we can tell which magnet ſhall prevail. But the unfolding even of theſe caſes would take a great deal of room, and muſt be omitted here. Beſides, we are too imperfectly acquainted with the degree of magnetiſm induced on the various parts of an iron rod, and the degree of magnetiſm inherent in the various parts of the magnets, to be able to ſay, with certainty, even in thoſe ſimple caſes, on which ſide the ſuperiority of attraction will remain.

58
Making of artificial magnets.

We may now proceed to deduce from this theory (for ſo it may juſtly be called, ſince all is reduced to one fact) the proceſs for communicating magnetiſm to bodies fitted for receiving and retaining it; that is, the method of making artificial magnets. We ſhall not employ much time on this, becauſe the moſt approved methods have been delivered at length in the article MAGNETISM of the *Encyclopædia Britannica*; and therefore we ſhall juſt make ſuch obſervations on them as ſerve to confirm, or to perfect them by the theory. We acknowledge, that we do not know the internal proceſs by which magnetiſm is induced, nor even in what this magnetiſm conſiſts. All that we know is, that the bringing the pole of a magnet near to any magnetiſable matter, produces a magnetiſm of the kind oppoſite to that of the pole employed. We know that this is the caſe with both poles, and that it obtains at all the diſtances where magnetiſm is obſerved. We know that the action of one pole is contrary to that of the other; that is, it counteracts the other, prevents it from producing its effect, and deſtroys it when already produced: and we know, that the production of theſe effects reſembles in its reſult the protruſion of ſomething fluid through the pores of the body, conſtipating it in all remote parts; as if the virtue of a pole reſided in this moveable matter. This is nearly all that we know of it; and by theſe facts and notions we muſt judge of the propriety and effect of all the proceſſes for magnetiſing bodies.

The moſt ſimple method of magnetiſing a ſteel bar, is to apply the north pole of a magnet to that end which we wiſh to render a ſouth pole. Attention to the effects of this application is very inſtructive. Have in readineſs a very ſmall compaſs needle, turning on its pivot. It ſhould not exceed half an inch in length, and ſhould be as hard tempered as poſſible, and ſtrongly impregnated. Immediately after the application of the magnet, carry the needle along the ſide of the bar. If the bar be long, and very hard, we ſhall obſerve a ſouth polarity at the place of contact; a north polarity at a ſmall diſtance from it; beyond this a weak ſouth polarity; then a weak and diffuſed north polarity, &c.; toward the remote end the polarity will be found very uncertain. The ſame thing may be diſcovered by laying a ſtiff paper on the bar, and ſprinkling iron filings over it, and then gently tapping the paper, to make them arrange themſelves in curve lines; which will point out the various poles, and ſhew whether they are diffuſed or conſtipated. It is very amuſing and inſtructive to obſerve the progreſs of this impregnation. In a few minutes after the firſt application of the magnet, we ſhall perceive the ſtate of magnetiſm very ſenſibly changed. The north pole will be farther from the magnet, and will be more diſtinct; the ſouthern polarity will alſo be protruded, and may appear for a moment at the remote extremity. The change advances; but the progreſs is more ſlow, and at laſt is inſenſible. When the bar is not harder than the temper of a cutting tool, the proceſs is ſoon over; and if the bar is but ſix or eight inches long, the remote end ſhews the north polarity in a very few minutes. When the bar is very hard, the progreſs of impregnation is greatly expedited by ſtriking it ſo as to make it ſound. If it be ſuſpended by a ſtring in a vertical poſition, and the magnet applied to its lower end, the ſtriking it with a key will make it ring; and in this way make the progreſs of magnetization very quick: but it does not allow it to acquire all the magnetiſm that can be given it by a very ſtrong magnet.

But this is a bad way of impregnation. It is ſeldom that uniform magnetiſm, with only two poles, and thoſe of

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(B.) So Claudian.——" Nam ferro nurunt vitam, ferrique vigore
Veſcitur, hoc dulces epulas, hoc pabula novit
Hinc proprias renovat vires, hinc fuſa per artus
Aſpera ſecretum ſervant alimenta vigorem
Hoc abſente perit, triſti morientia torpent
Membra fame, venaſque ſitis conſumit apertas."

Pliny ſays, " Sola hæc materia (ferrum) vires ab eo lapide, accipit retinetque longo tempore, aliud apprehendens ferrum, ut annulorum catena ſpectetur interdum, quod imperitum vulgus ferrum appellat vivum.

of equal ſtrength, can be given. Even when there are but two, the remote pole is generally diffuſed, and therefore feeble. It is much improved by employing two magnets, one at each end. And if the bar is not more than ſix or eight inches long, and good magnets are employed, the magnetiſm is abundantly regular. This, accordingly, is practiſed for the impregnation of dipping needles, which muſt not be touched, leſt we diſturb the centre of gravity of the needle. But in all caſes, this method is tedious, and does not give ſtrong magnetiſm.

The method which was uſually practiſed before we had obtained a pretty clear knowledge of magnetiſm, was to apply the pole of a magnet to one end of the bar, and paſs it along to the other end, preſſing moderately. This was repeated ſeveral times on both ſides of the bar, always beginning the ſtroke at the ſame end as at firſt, and, in bringing the magnet back to that end, keeping it at a diſtance from the bar. The effect of this operation was to leave the end at which we began the ſtroke poſſeſſed of the polarity of the pole employed.

A general notion of the proceſs may be given as follows, obſerving, however, that there occur very many great and capricious anomalies. When the north pole N (fig. 16.) of the magnet A is ſet on the end C of the bar CBD, a ſouth pole is produced at C, and a north pole at D, when the length of the bar is moderate. As the magnet advances ſlowly along the bar, the ſouthern polarity at C firſt increaſes, then diminiſhes, and vaniſhes entirely when N has arrived at a certain point *a*; after which, a northern polarity appears at C, and increaſes during the whole progreſs of the magnet. In the mean time, the northern polarity firſt produced at D increaſes till the magnet reaches a certain point *e*, then diminiſhes, vaniſhes when the magnet reaches a certain point *f*; after which, a ſouthern polarity appears at D, which increaſes till the magnet reaches D. Mr Brugmann, who firſt attended minutely to theſe particulars (for Gilbert ſpeaks of them pointedly), calls *a* and *f points of indifference*, and *e* the *culminating* point of the pole D, and *i* the culminating point of the pole C. Hardly can any general rule be given for the ſituation of theſe points, nor even for the order in which they ſtand; ſo great and capricious are the anomalies in an amazing ſeries of experiments narrated by Brugmann and by Van Swinden. Repeating the operation, and beginning at C, the northern polarity there is weakened (ſometimes deſtroyed), then reſtored, and continually increaſed during the reſt of the ſtroke. The ſouthern polarity at D is alſo firſt weakened, and ſometimes deſtroyed; then reſtored, and finally augmented. The points *i*, *a*, *e*, *f*, change their ſituations, and frequently their order.

Van Swinden has attempted to deduce ſome general laws from his immenſe liſt of experiments, avoiding every conſideration of a hypotheſis, or the leaſt conjecture by what means theſe faculties are excited. But though we have peruſed his inveſtigation with care and candor, we muſt acknowledge, that we have not derived any knowledge which can help us to predict the reſult of particular modes of treatment with any greater preciſion than is ſuggeſted by a ſort of common ſenſe, aided (or perhaps perverted) by a vague notion, that theſe energies reſide in ſomething, which avoids the pole of the ſame name, carrying along with it this diſtinctive energy or polarity. This conception tallies perfectly with theſe obſervations of Brugmann and Van Swinden; and admits of all the anomalies in the ſituation of Bergmann's indifferent and culminating points, if we only ſuppoſe that this motion is obſtructed by the particles of the body. We muſt leave this to the reflection of the reader, who will *gueſs* how, when the magnet is between C and *i*, this ſubſtance, avoiding the pole N of the magnet, eſcapes below it, and goes toward the farther end. As the magnet advances, it drives ſome of this back again, &c. &c. This is gratuitous; but it aids the fancy, which, without ſome conception of this kind, has no object of ſteady contemplation. We have no thought when we ſpeak of the generating at C, or *a*, or *e*, a faculty of ſome kind, by the exertion of the ſame faculty in N. The conception is too abſtracted, and much too complex. We muſt content ourſelves with knowing, that N produces a ſouth pole immediately under it, and a north pole everywhere elſe, or endeavours to do ſo. It is unneceſſary to inſiſt longer on this method: Common ſenſe ſhews it to be a very injudicious one.

This method was greatly improved by beginning the friction at the centre. Apply the north pole at the centre or middle of the bar, and draw it over the end intended for the ſouth pole. Having done this ſeveral times to one end on both ſides, turn the magnet, applying its ſouth pole to the middle of the bar, and drawing it ſeveral times over the end intended for the north pole.

It was ſtill more improved by employing two magnets at once, placed as in fig. 17. on the middle B of the bar, and drawing them away from each other, over the ends of it, as ſhewn by the directing darts, and repeating this operation. It is plain that, as far as we underſtand any thing of this matter, this proceſs muſt be much preferable to either of the former two. The magnets A and E certainly concur in producing a properly diſpoſed magnetiſm on all that lies between them; and therefore on the whole bar at the end of each ſtroke. The end C muſt become a north, and D a ſouth pole. Still, however, as the ſtroke goes on to the point of indifference, each magnet tends to weaken the polarity of the parts ſituated beyond it.

This method continued to be practiſed till about the year 1750. Mr Canton, availing himſelf of the experiments of Mr Mitchell of Cambridge, publiſhed his method by the DOUBLE TOUCH as it is called. See *Monthly Review* for 1785

59
Method of double touch.

We need not [illegible]peat what has been detailed in the *Encyclopedia*, MAGNETISM, p. 440, &c. and ſhall only make ſome obſervations on the peculiar advantages of this proceſs, as preſcribed by Mitchell, Canton, and improved by Mr Antheaume, in his memoir *ſur les Aimans artificiels* 1766, which was crowned by the Academy of Sciences. (See alſo diſſertations on the ſubject by *Le Maire and Du Hamel*, 1745).

There is an evident propriety in the arrangement invented by Mr Mitchell, repreſented in fig. 18. The magnetiſm induced on the two pieces of ſoft iron AD and BC is an excellent method for *ſecuring* every acceſſion of magnetiſm to either of the bars. A good deal depends on the proper ſize and length of theſe pieces; and our ignorance of the interior proceſs obliges us to have recourſe to experiment alone for aſcertaining this. Whatever circumſtances induce the ſtrongeſt magnetiſm on thoſe pieces of iron, will cauſe them to produce the greateſt effect on the ſteel bars; and this will be indicated by a greater attraction. Therefore that diſtance will be the beſt which enables two bars AB and DC to lift the greateſt weight hung on the piece AD or BC. When we impregnated bars whoſe breadth was about one tenth of their length, and their thickneſs about one-half of their breadth, we found, that if AD was about one-fourth, or nearly one-third, of AB, they carried more than if it was either much longer or much ſhorter. Mr Antheaume's addition of the two great bars of iron E and F makes a ſenſible improvement of the *beginning* of the impregnation, when very weak magnets are employed; but did not ſeem to us to be of any farther ſervice on the table. This is agreeable to any theory which can be eſtabliſhed by what we have ſaid hitherto.

The method of employing the magnets A and E (fig. 19.), preſcribed by Mitchell and Canton, is extremely judicious. The meeting of the diſſimilar poles at top increaſes the magnetiſm of each. The two diſſimilar poles F and G, certainly tend to give a regular and proper magnetiſm to the part FG of the bar which lies between them; and this is the caſe on whatever part of the bar they are placed. But each pole tends to deſtroy the preſent magnetiſm of what lies between it and the pole of the bar on that ſide. But mark— they tend to produce the deſired magnetiſm on what lies between them with the *ſum* of their forces; while each tends to deſtroy the magnetiſm of the part without it by the *difference* only of their forces. Therefore, on the whole, as they are moved to and fro along the bar, and the foremoſt one even made to paſs over the end of it a little way, they always add to the magnetiſm already acquired. This conſideration ſeems to enjoin ſetting F and G extremely near each other; for this ſeems to increaſe the ſum, and to diminiſh the difference of their action. But it may be a queſtion, Whether we gain more by ſtrongly magnetiſing a very ſmall part during the very ſhort while that the magnets paſs over it, or by acting on more of the bar at once, and continuing a weaker action for a longer while on this larger portion. Mr Æpinus adds another conſideration depending on his notion of the internal proceſs; but we defer this to another opportunity. The ſafeſt direction ſeems to be, to place them at the diſtance which enables them to lift the greateſt weight. They are then undoubtedly acting with the greateſt effect.

Mr Antheaume directs to place the touching magnets as in fig. 20. for a reaſon to be mentioned afterwards. Mr Æpinus alſo recommends it for reaſons founded on his own hypotheſis. We muſt ſay, that, in our trials, we have found this method very ſenſibly ſuperior, eſpecially in the latter parts of the operation, when the reſiſtance to farther impregnation becomes nearly a balance for the accumulating power of the magnets; and we conſider this as no inconſiderable argument for the juſtice of Mr Æpinus's hypotheſis.

The great advantage of this method is the regularity of the magnetiſm which it produces. We never find more than two poles; and when the bars are hard, and of uniform texture, the polarity is very little diffuſed, and ſeemingly confined to a very ſmall ſpace at the very extremities of the bar. This is indeed a prodigious advantage in point of ſtrength. It is no leſs ſo in order to fit the magnets for experiments on the law of magnetic action; for the latitude which the diffuſed condition of the poles gives in the ſelection of the points from which the diſtances are to be computed, has hitherto hindered us from pronouncing on the law of magnetic action with the preciſion of which we think it fully ſuſceptible. This method alſo is the only one by which we have been able to impregnate two bars joined end to end, conſidering them as one bar. We have ſometimes (though very rarely) ſucceeded in this; ſo that when filings were ſtrewed over them, the appearance could not be diſtinguiſhed from a ſingle bar.— *N. B.* Yet even in this caſe, in one experiment with two bars of ſix inches long, treated as one, when it could not be diſtinguiſhed, either by the appearance of the filings, or by going round it very near with a compaſs needle, a very ſmall compaſs needle diſcovered a neutral point, and a reverſion of polarity ſimilar to fig. 14. at F, ſhewing that it was really acting as two bars. Perhaps it muſt always be ſo; and this queſtion is of conſiderable importance in the eſtabliſhment of any theory of the internal proceſs.

It deſerves remark, that, in order to ſucceed in this attempt, a very conſiderable preſſure is neceſſary. We were obliged to clean the ends of the bars very carefully, and to force the frame of bars and ſoft pieces of iron ſtrongly together by wedges, in the manner of a form of types. We thought that wetting the ends of the bars with pure water aided the experiment; and we are *very certain* that oil not only greatly obſtructed it, but even ſenſibly impeded the common proceſs. We had put a ſingle drop of oil on a pair of bars which we were touching in the common Cantonian method, that the magnets might be more eaſily drawn along them; but we were ſurpriſed at finding that we could not give a ſtrong impregnation. The oil undoubtedly prevents the cloſe contact. We found the fineſt gold leaf produce the ſame effect in a great degree; as alſo talc, of which a ſquare inch weighed $\frac{1}{32}$th of a grain. We do not infer any thing like obſtruction to the paſſage of ſomething material, but rather aſcribe it to mere diſtance; although we are of opinion, that in the impregnation of two contiguous bars, ſo that the magnetiſm (whatever it is) is diſpoſed *preciſely* as in one bar, there *is* a material transference. But we ſhall ſpeak of this in its due place.

It is not unworthy of remark, that we found bars to acquire more powerful magnetiſm when pretty well poliſhed than when rough. But we alſo found, that bars conſiderably rough acquired the firſt degrees of it much more expeditiouſly than thoſe which are ſmooth; although we never could bring them to that high degree of magnetiſm that the ſame bars acquired after they had been poliſhed. We think it probable, that the tremors, occaſioned by the rough and harſh ſurfaces of the hard ſteel, are the cauſes of this phenomenon.

Some more obſervations on this method of the double touch will be made afterwards, when we conſider the hypotheſis of Mr Æpinus: and we conclude the preſent ſubject, by attempting to explain ſome puzzling appearances which frequently occur in making artificial magnets.

60 Difficulties explained.

A bar touched by a very ſtrong magnet has been ſaid by Muſchenbroek to be impaired by going over it with a weaker magnet. If it had been made as ſtrong as poſſible, the weaker magnet, when paſſed over it in the way practiſed by Muſchenbroek, muſt *firſt* deſtroy part of this magnetiſm; and having done ſo, it is unable to raiſe it anew to the ſame degree of vigour.

Yet (ſays Muſchenbroek with ſurpriſe) a large bar of common iron has greatly improved the magnet. A very large piece of iron *muſt* do this (eſpecially if ſhaped like a horſeſhoe, and applied with both heels), if the bar be not already at its maximum.

It was thought wonderful, that, in the method of double touch, not only was the magnetiſm of the magnets employed not impaired, but, beginning with two magnets, whoſe power is almoſt inſenſible, and repeating the operations in the preciſe manner deſcribed by Mitchell or Canton, not only the bars intended to be made magnetical, but alſo the magnets employed, may be brought to their higheſt poſſible ſtate of magnetiſm. This is in evident conformity to the general facts of induced magnetiſm, and affords the ſtrongeſt proof that nothing is communicated in this operation, but that powers reſiding in the bars are excited, or brought into action. The manipulation merely *gives occaſion* to this action, as a ſpark of fire kindles a city.

61
Explanation of the beginning of Savery, Canton, and Antheaume's proceſs.

There ſtill remain ſome circumſtances of this method, as practiſed by Savery, Canton, and Antheaume, which are extremely curious and important.

Mr Savery had obſerved a ſmall bit of ſteel acquire very ſenſible magnetiſm by lying long in contact with the lower end of a great window bar. Telling this to a friend, he was, for the firſt time, informed, that this had been long obſerved, and that Dr Gilbert had made ſome curious inferences from it. Mr Savery wanted ſome magnets, and was at a diſtance from town. Reflecting, like a philoſopher, on what he had heard and obſerved, he ſaw here a ſource of magnetiſm which he could increaſe, in the manner commonly practiſed in making magnets. He placed the bar AB (fig. 21.) to be magnetiſed between two great bars of common iron C and D, placing all the three in the magnetical direction. He took another bar EF, and put two little pieces of iron, like the armour of a loadſtone, on its ends; and with thoſe ends he rubbed the bar AB, rubbing the upper half of it with the end F, and the lower with the end E. The reſult of this was a very briſk magnetiſm in a few minutes, which, by various well deviſed alternations, he brought to its higheſt degree. His numerous experiments publiſhed in the Philoſophical Tranſactions in 1746, contain much curious information, highly deſerving the attention of the philoſophers. Mr Canton, proceeding on the ſame principle, that bars of iron, which have been long in a vertical poſition, acquire an efficient magnetiſm, begins his operations by placing his ſteel bar on the head of a kitchen poker, and rubs it with the lower end of a pair of kitchen tongs. Mr Antheaume adheres more ſtrictly to the inferences from the principle of terreſtrial magnetiſm, and repeats preciſely the previous diſpoſition of things practiſed by Mr Savery, placing his little ſteel bar AB (fig. 22.) between two great bars C and D of common iron, and arranging the whole in the magnetic direction. Then, proceeding moſt judiciouſly on the ſame principle, he greatly improves the proceſs, by employing two bars EF and GH for the touch, holding them about an inch apart, inclined about 15° to the bar AB. It is plain, that the lower end of each of theſe five bars is a north pole, and the upper end a ſouth pole. Therefore the poles F and G concur in giving the proper magnetiſm to the portion FG of the ſteel bar which is between them; and by rubbing it with theſe poles up and down, overpaſſing each extremity about half an inch, he muſt ſoon give to the bar AB a regular magnetiſm; weak, perhaps, but to be afterwards increaſed in the Cantonian method, on a horizontal table. In this manner did Mr Antheaume make magnets of very great ſtrength in 1766. See his *Diſſertation* already quoted.

62
Gilbert's terreſtrial magnetiſm.

Theſe obſervations naturally bring us to the PHYSIOLOGIA NOVA DE MAGNETE ET CORPORIBUS MAGNETICIS of Dr Gilbert; a diſcovery which the ſagacious Kepler claſſes among the greateſt in the annals of ſcience.

It could not be that a phenomenon ſo general, and ſo intereſting and important as the natural polarity of magnetic bodies, would be long known without exciting curioſity about its cauſe. Accordingly the philoſophers of the 16th century ſpeculated much about it, and entertained a variety of opinion, if that can be called an opinion which can hardly be ſaid to expreſs a thought. We have in *Marſigli Ficino* a ſhort notice of many of theſe opinions. Some maintained that the needle was directed by a certain point in the heavens, as if that were ſaying more than that it always pointed one way. Others, with more appearance of reaſoning, aſcribed the direction to vaſt magnetic rocks. But all this was without giving themſelves the trouble of trying to aſcertain what ſituation of ſuch rocks would produce the direction that is obſerved. Fracaſtori was, if we miſtake not, the firſt who thought this trouble at all neceſſary; and he obſerves very ſenſibly, that if thoſe rocks are ſuppoſed to be in any place yet viſited by navigators, and if they act as loadſtones do (a circumſtance which he ſays muſt be admitted, if we attempt to explain), the direction of the needle will be very different from what we know it to be. He therefore places them in the inacceſſible polar regions, but not in the very pole. Norman, the diſcoverer of the dip of the mariner's needle, or of the true magnetic direction, was naturally led by his diſcovery to conceive the directing cauſe as placed in the earth; becauſe the north point of the needle, in every part of Europe, points very far below the horizon. But although he calls the treatiſe in which he announces his diſcovery the *New Attractive*, he does not expreſs himſelf as ſuppoſing the needle to be attracted by any point within the earth, but only that it is always directed to that point.

It is to Dr Gilbert of Colcheſter that we owe the opinion now univerſally admitted, that magnetic polarity is a part of the conſtitution of this globe. Norman had, not long before, diſcovered, that if a ſteel needle be very exactly balanced on a horizontal axis, like the beam of a common balance, ſo that it would retain any poſition given it, and if it be then touched with a magnet, and placed on its axis in the magnetic meridian, it is no longer in equilibrio, but (at London) the north point of it will dip 72 or 73 degrees below the horizon. He did not, however, publiſh his diſcovery till he had obtained information how it ſtood in other parts of the world. The differences in the variation in different places naturally ſuggeſted the neceſſity of this to him. Being a maker of mariners compaſſes,

paſſes, and teacher of navigation in London, he had the faireſt opportunities that could be deſired, by furniſhing dipping needles to ſuch of the navigators, his ſcholars, as he knew moſt able to give him good information. And the accounts which he received made his diſcovery, when announced to the world, a very complete thing; for the commanders of ſhips engaged in long voyages, and particularly to China, informed him that, in the vicinity of the equator, his dipping needles remained parallel to the horizon, but that in coming toward the north pole, the north end of the needle was depreſſed, and that the ſouth end dipped in like manner at the Cape of Good Hope, and in the Indian Ocean; that the needle gradually approached the horizontal poſition as the ſhip approached the equator, but that in coming to the north of it at Batavia, the north point again dipped, and at Canton was ſeveral degrees below the horizon.

On theſe authorities, Norman boldly ſaid that, in the equatoreal regions, the needle was horizontal, and that either end dipped regularly as it approached either pole; and that in the poles of the earth, the needle was perpendicular to the horizon. He therefore announced this as a diſcovery, not only ſingularly curious, but alſo of immenſe importance; for by means of a dipping needle the latitude of a ſhip at ſea may be found without ſeeing the ſun or ſtars.

Dr Gilbert, comparing this poſition of the compaſs needle with the poſitions which he had obſerved ſmall needles aſſume in his numerous experiments in relation to a magnet, as we have deſcribed at great length, was naturally led to the notion of the earth's being a great loadſtone, or as containing one, and that this arranged the dipping, or, in general, the mariner's needle, in the ſame manner as he obſerved a great magnet arrange a ſmall needle poiſed on its pivot. He therefore compoſed his *Phyſiologia Nova de Magnete, et de Tellure magno Magnete*; in which he notices ſo many points of reſemblance to the directive power of a magnet, that the point ſeems no longer to admit of any doubt. Dr Gilbert's theory may be thus expreſſed:

All the phenomena of natural magnetiſm are analogous to what we ſhould obſerve, if the earth were a great magnet, having its poles near the poles of the earth's equator, the north pole not far from Baffin's Bay, and the ſouth pole nearly in the oppoſite part of the globe. A dipping needle, under the influence of this great magnet, muſt arrange itſelf in a plane which paſſes through the poles of the magnet, the poſition of which plane is indicated (at leaſt nearly) by the ordinary compaſs needle; and it will be inclined to the horizon ſo much the more as we recede from the equator of the great magnet.

This opinion of Dr Gilbert was not leſs ingenious than important; and if firmly eſtabliſhed, it furniſhes a complete theory of all the phenomena of magnetiſm. But obſervations were neither ſufficiently numerous in the time of Dr Gilbert, nor ſufficiently accurate, to enable that great genius to aſſign the poſition of this great magnet, nor the laws of its action. The theory was chiefly founded on the phenomena of the dipping needle; phenomena which might have been unknown for ages, had the firſt notice of them fallen into any other hands than Norman's. They are not, like thoſe of variation, which might be made by any ſailor. They require for their exhibition a dipping needle, and the attention to circumſtances which can occur only to a mathematician. A dipping needle is to this day, notwithſtanding all our improvements in the arts, one of the moſt delicate and difficult taſks that an inſtrument maker can take in hand, and a good one cannot be had for leſs than twenty guineas. We are confident that ſuch as even Norman could make were far inferior to what are now made, and quite unfit for uſe at ſea while the ſhip is under ſail, although they may be tolerably exact for an obſervation of the dip in any port; and we preſume that it was ſuch obſervations only that Norman confided in. Our readers will readily conceive the difficulty of poiſing a needle with ſuch a perfect coincidence of its centre of gravity and axis of motion, and perfect roundneſs of this axis, that it ſhall remain in any poſition that is given it. Add to this, that a grain of duſt, inviſible to the niceſt eye, getting under one ſide of this axis, may be ſufficient for making it aſſume another poſition. It muſt alſo be a difficult matter to preſerve this delicate thing, ſo as that no change can happen to it. Beſides, all this muſt be performed on a piece of tempered ſteel which we are certain has no magnetiſm. Where can this be got, or what can inſure us againſt magnetiſm? Nor is there leſs difficulty in making the obſervations without great riſk of error. If the needle, moveable only in a vertical plane, be not ſet in the plane of a magnetic meridian, it will always dip too much. At London, where the magnetic direction is inclined 73° to the horizon, if it be in a plane 20° from the magnetic meridian, it will ſtand almoſt perpendicular; for it is eaſy to ſee, by the mechanical reſolution of forces, that it will take the poſition which brings it neareſt to the true magnetic direction. This, we think, is confirmed by ſeveral of Norman's and other old obſervations of dip. They are much greater than they have been ſince found in the ſame places.

63
Daniel Bernoulli's dipping needle.

Mr Daniel Bernoulli has given a very ingenious principle, by which we can make a dipping needle which will give a very accurate obſervation on ſhore; and being ſo eaſily executed, it deſerves to be generally known. Let a dipping needle be made in the beſt manner that can be done by a workman of the place, and balanced with ſome care before impregnation, ſo that we may be certain that when touched it will take nearly the true dip. Touch it, and obſerve the dip. Deſtroy its magnetiſm, and then alter its balance in ſuch a manner that, without any magnetiſm, it will arrange itſelf in the inclination of the obſerved dip. Now touch it again, giving it the ſame poles as before. It is plain that it will now approach exceedingly near indeed to the true dip, becauſe its want of *perfect* equilibrium deranged it but a few degrees from the proper direction. If this ſecond obſervation of the dip ſhould differ ſeveral degrees from the firſt, by the inaccurate firſt formation of the needle, it will be proper to repeat the operation. Very rarely indeed will the third obſervation of the dip vary from the truth half a degree.

Mr Bernoulli makes this ſimple contrivance anſwer the purpoſe of an univerſal inſtrument in the following ingenious manner. A very light braſs graduated circle EFG (fig. 23.) is fixed to one ſide of the needle, concentric with its axis, and the whole is balanced as nicely as poſſible before impregnation. A very light index

CD is then fitted on the axis, ſo as to turn rather ſtiffly on it. This will deſtroy the equilibrium of the needle. If the needle has been made with perfect accuracy, and perfectly balanced, the addition of this index would cauſe it always to ſettle with the index perpendicular to the horizon, whatever degree of the circle it may chance to point at. But as this is ſcarcely to be expected, ſet the index at various degrees of the circle, and note what inclination the unmagnetic needle takes for each place of the index, and record them all in a table. Suppoſe, for example, that when the index is at 50, the needle inclines 46° from the horizon. If in any place we obſerve that the needle (rendered magnetic by lying between two ſtrong magnets), having the index at 50, inclines 46°, we may be certain that this is the dip at that place; for the needle is not deranged by the magnetiſm from the poſition which gravity alone would give it. As we generally know ſomething of the dip that is to be expected in any place, we muſt ſet the index accordingly. If the needle does not ſhew the expected dip, alter the poſition of the index, and again obſerve the dip. See whether this ſecond poſition of the index and this dip form a pair which is in the table. If they do, we have got the true dip. If not, we muſt try another poſition of the index. Noticing whether the agreement of this laſt pair be greater or leſs than that of the former pair, we learn whether to change the poſition of the index in the ſame direction as before, or in the oppoſite. The writer of this article has a dipping needle of this kind, made by a perſon totally unacquainted with the making of philoſophical inſtruments. It has been uſed at Leith, at Cronſtadt in Ruſſia, at Scarborough, and at New York, and the dip indicated by it did not in any ſingle trial differ 1¼ degrees from other trials, or from the dip obſerved by the fineſt inſtruments. He tried it himſelf in Leith Roads, in a rough ſea; and does not think it inferior, either in certainty or diſpatch, to a needle of the moſt elaborate conſtruction. It is worthy of its moſt ingenious author, and of the public notice, becauſe it can be made for a moderate expence, and therefore may be the means of multiplying the obſervations of the dip, which are of immenſe conſequence in the theory of magnetiſm, and for giving us an accurate knowledge of the magnetical conſtitution of this globe.

64 Opinions concerning the great magnet contained in this globe.

This knowledge is ſtill very imperfect, owing to the want of a very numerous collection of obſervations of the dip. They are of more importance than thoſe of the horizontal deviations from the meridian. All that we can ſay is, that the earth acts on the mariner's needle as a great loadſtone would do. But we do not think that the appearances reſemble the effects of what we would call a good loadſtone, having the regular magnetiſm of two vigorous poles. The dips of the needle in various parts of the earth ſeem to be ſuch as would reſult from the action of an extremely irregular loadſtone, having its poles exceedingly diffuſed. The increaſe of the dip, as we recede from thoſe places where the needle is horizontal, is too rapid to agree with the ſuppoſition of two poles of conſtipated magnetiſm, whether we ſuppoſe the magnetic action in the inverſe ſimple or duplicate ratio of the diſtances, unleſs the great terreſtrial magnet be of much ſmaller dimenſions than what ſome other appearances oblige us to ſuppoſe. If there be four poles, as Dr Halley imagined, it will be next to impoſſible to aſcertain the poſitions of the dipping needle. It will be a tangent to one of the ſecondary magnetic curves, and theſe will be of a very intricate ſpecies. We cannot but conſider the diſcovery of the magnetic conſtitution of this globe as a point of very great importance, both to the philoſopher and to ſociety. We have conſidered it with ſome care; but hitherto we have not been able to form a ſyſtematic view of the appearances which gives us any ſatisfaction. The well informed reader is ſenſible, that the attempt by means of the horizontal or variation needle is extremely tedious in its application, and is very unlikely to ſucceed; at the ſame time it muſt be well underſtood. The two diſſertations by Euler, in the 13th and 22d volumes of the Memoirs of the Royal Academy at Berlin, are moſt excellent performances, and give a true notion of the difficulty of the ſubject. Yet, even in theſe, a circumſtance is overlooked, which, for any thing we know to the contrary, may have a very great effect. If the magnetic axis be far removed from the axis of revolution, as far, for example, as Mr Churchman places it, the magnetic meridians will be (generally) much inclined to the horizon; and we ſhall err very far, if we ſuppoſe (as in Euler's calculus) that the dipping needle will arrange itſelf in the vertical plane, paſſing through the direction of the horizontal or variation needle; or if we imagine that the poles of the great magnet are in that plane. We even preſume to think that Mr Euler's aſſumption of the place of his fictitious poles (namely, where the needle is vertical), in order to obtain a manageable calculus, is erroneous. The introduction of this circumſtance of inclination of the magnetic meridians to the horizon, complicates the calculation to ſuch a degree as to make it almoſt unmanageable, except in ſome ſelected ſituations. Fortunately, they are important ones for aſcertaining the places of the poles. But the inveſtigation by the poſitions of the dipping needle is incomparably more ſimple, and more likely to give us a knowledge of a multiplicity of poles. The conſideration of the magnetic curves (in the ſenſe uſed in the preſent article), teaches us that we are not to imagine the poles immediately under thoſe parts of the ſurface where the needle ſtands perpendicular to the horizon, nor the magnetic equator to be in thoſe places where the needle is horizontal; a notion commonly and plauſibly entertained. Unfortunately our moſt numerous obſervations of the dip are not in places where they are the moſt inſtructive. A ſeries ſhould be obtained, extending from New Zealand northward, acroſs the Pacific Ocean to Cape Fairweather on the weſt coaſt of North America, and continued through that part of the continent. Another ſeries ſhould extend from the Cape of Good Hope, up along the weſt coaſt of Africa to the tropic of Capricorn; from thence acroſs the interior of Africa (where it would be of great importance to mark the place of its horizontality) through Sicily, Italy, Dalmatia, the eaſt of Germany, the Gulph of Bothnia, Lapland, and the weſt point of Greenland. This would be nearly a plane paſſing through the probable ſituations of the poles. Another ſeries ſhould be made at right angles to this, forming a ſmall circle, croſſing the other near Cape Fairweather. This would paſs near Japan, through Borneo, and the weſt end of New Holland; alſo near Mexico, and a few degrees weſt of Eaſter Iſland. In this place, and at Borneo, the

See VARIATION, *Encycl.*

the inclination of the magnetic plane to the horizon would be conſiderable, but we cannot find this out. It may, however, be diſcovered in other points of this circle, where the dip is conſiderable. We have not room in this ſhort account to illuſtrate the advantages derived from theſe ſerieſes; but the reflecting reader will be very ſenſible of them, if he only ſuppoſes the great magnet to be accompanied by its magnetic curves, to which the needle is always a tangent. He will then ſee that the firſt ſeries from New Zealand to Cape Fairweather, and the ſecond from Cape Fairweather round the other ſide of the globe, being in one plane, and at very different diſtances from the magnetic axis, muſt contain very inſtructive poſitions of the needle. But we ſtill confeſs, that when we compare the dips already known with the variations, they appear ſo irreconcileable with the reſults of an uniform regular magnetiſm, that we deſpair of ſucceſs. Every thing ſeems to indicate a multiplicity of poles, or, what is ſtill more adverſe to all calculation, an irregular magnetiſm with very diffuſed polarity.

Much inſtruction may ſurely be expected from the obſervations of the Ruſſian academicians and their eleves, who are employed in ſurveying that vaſt empire; yet we do not meet with a ſingle obſervation of the dip of the needle in all the bygone publications of that academy, nor indeed are there many of the variation.

65 And concerning the ſituation of its poles.

For want of ſuch information, philoſophers are extremely divided in their opinions of the ſituation of the magnetic poles of this globe. Profeſſor Krufft, in the 17th volume of the Peterſburgh Commentaries, places the north pole in lat. 70° N. and long. 23° W. from London; and the ſouth pole in lat. 50° S. and long. 92° E.

Wilcke of Stockholm, in his indication chart (*Swed. Mem.* tom. xxx. p. 218.), places the north pole in N. Lat. 75°, near Baffin's Bay, in the longitude of California. The ſouth pole is in the Pacific Ocean, in lat. 70° S.

Churchman places the north pole in lat. 59° N. and long. 135° W. a little way inland from Cape Fairweather; and the ſouth pole in lat. 59° S. Long. 165° E. due ſouth from New Zealand.

A planiſphere by the Academy of Sciences at Paris for 1786, places the magnetic equator ſo as to interſect the earth's equator in long. 75°, and 155° from Ferro Canary Iſland, with an inclination of 12 degrees nearly, making it a great circle very nearly. But we are not informed on what authority this is done; and it does not accord with many obſervations of the dip which we have collected from the voyages of ſeveral Britiſh navigators, and from ſome voyages between Stockholm and Canton. Mr Churchman has given a ſketch of a planiſphere with lines, which may be called parallels of the dip. Thoſe parts of each parallel that have been aſcertained by obſervation are marked by dots, ſo that we can judge of his authority for the whole conſtruction. It is but a ſketch, but gives more ſynoptical information than any thing yet publiſhed. The magnetic equator cuts the earth's equator in long. 15°, and 195° E. from Greenwich, in an angle of nearly 17 degrees. The circles of magnetic inclination are not parallel, being conſiderably nearer to each other on the ſhort meridian than on its oppoſite. This circumſtance, being founded on obſervation, is one of the ſtrongeſt arguments for the exiſtence of a magnet of tolerable regularity, as the cauſe of all the poſitions of the compaſs needle; for ſuch *muſt* be the poſitions of the circles of equal dip, if the axis of this magnet is far removed from the axis of rotation, and does not interſect it.

66. Now, if the ſituation of the poles be any thing near the average or medium of theſe determinations, and if we form all our notions by analogy, comparing the poſitions of the compaſs needle in relation to the great terreſtrial magnet, with the poſitions aſſumed by a ſmall needle in the neighbourhood of a magnet, we muſt conclude, that the magnetical conſtitution of this globe has little or no reference to its regular external form. The axis of the magnet is very far removed from that of the globe (at leaſt 1500 miles), and is not nearly parallel to it, nor in the ſame plane. It required the ſagacity and the ſkill of a Euler to ſubject ſuch anomalous magnetiſm to any rules of computation; and every perſon qualified to judge of the ſubject muſt allow his diſſertation in the 13th volume of the Berlin Memoirs to be a work of wonderful reſearch. It is a very agreeable thing to ſee ſuch a conformity between the lines which expreſs the regular magnetiſm of Euler's diſſertation, and the lines drawn by Dr Halley from obſervation, and which appeared to himſelf ſo capricious, that he deſpaired (notwithſtanding his conſummate ſkill in geometry) of their ever being reduced to a mathematical and preciſe ſyſtem.

67 Confirmations of Dr Gilbert's phyſiology.

Without detracting from the merit of Dr Gilbert, we may preſume to ſay that his notion of the earth's being a great magnet was not, in his mind, more than a ſagacious conjecture, formed from a very general and even vague compariſon. Yet the compariſon was ſufficiently good to give him great confidence in his opinion that the action of this great magnet, in perfect conformity to what we obſerve in our experiments with magnets, is the ſource of all the magnetiſm that we obſerve. If there was nothing elſe in proof of the juſtneſs of his theory, it is abundantly proved by the beautiful experiment of Mr Henſhaw, mentioned in the article Variation, *Encycl.* p. 621. col. 2. An iron bar held nearly upright, attracts the ſouth end of a compaſs needle with its lower end; and if that end of the bar be kept in its place, and the bar turned round till it becomes the upper end, the ſouth point of the needle immediately turns away from it, and the north end is now attracted. This experiment may be perfectly imitated with artificial magnetiſm.

Having ſupported a large magnet SAN (fig. 24.), ſo that its ends are detached from ſurrounding bodies, place a ſmall needle B (poiſed on its pivot) about three inches below the north pole N of the magnet, and in ſuch a ſituation that its polarity to the magnet may be very weak. Take now a ſmall piece of common iron, and hold it in the poſition repreſented at C. Its lower end becomes a north pole, attracting the ſouth pole of the needle. Keeping this in its place, turn round the piece of iron into the poſition D; the ſouth pole of B will now avoid it, and the north pole will be attracted. We directed the needle to be ſo placed, that its polarity, in relation to the magnet, may be weak. If it be ſtrong, it may act on the end of C or D like a magnet, and counteract the magnetiſm induced on C or D by vicinity to A.

An anonymous writer in the Philoſophical Tranſactions, N° 177. Vol. XV. relates ſeveral obſervations made during a voyage to the Eaſt Indies, which are quite conformable to this. A few leagues northweſt from the iſland Aſcenſion, the ſouth point of the compaſs needle hardly ſhewed any tendency to or from the lower end of an iron bar. It ſeemed rather to avoid the upper end; it was not in the leaſt affected by the middle of the bar; but when the bar was laid horizontal, in the magnetic direction, its two ends affected the diſſimilar ends of the compaſs needle very ſtrongly; but when horizontal, and lying at right angles to the magnetic direction, its polarity was altogether indifferent.

As the other phenomena of induced artificial magnetiſm have the ſame reſemblance to the phenomena of natural magnetiſm, a bar which has remained long in the vicinity of a magnet acquires magnetiſm (permanent) in the ſame way, and modified by the ſame circumſtances, as in natural magnetiſm. Hammering a bit of common iron in the immediate vicinity of a magnet, gives it very good magnetiſm. Expoſing a red hot bar to cool in the neighbourhood of a magnet has the ſame effect. Alſo quenching it ſuddenly has the ſame effect. Quenching a ſmall red hot ſteel bar between two magnets, was found by us to communicate a much ſtronger magnetiſm than we could give it by any other method. Its form indeed was very unfavourable for the ordinary method of touching; for it conſiſted of two little ſpheres connected by a ſlender rod, and could ſcarcely be impregnated in any other way than by placing it for a very long while between magnets. In all theſe experiments, the polarity acquired is preciſely ſimilar to that acquired by the ſame treatment in relation to this ſuppoſed great terreſtrial magnet. In ſhort, in whatever manner we purſue this analogy in our experiments, we find the reſemblance moſt perfect in the phenomena.

We cannot but think, therefore, that this new phyſiology of the magnet by Dr Gilbert is well eſtabliſhed; and we think ourſelves authoriſed to aſſume it as a propoſition fully demonſtrated, that the earth is a great magnet, or contains a great magnet, the agency of which produces the direction of the magnetic needle, and all the magnetiſm which iron acquires by long continuance in a proper poſition. It is this which made us ſay, in the beginning of this article, that attraction and polarity were not confined to magnets, but were properties belonging to all iron in its metallic ſtate. We now ſee the reaſon why any piece of iron brought very near to another piece will attract it—both become magnetical, in conſequence of the agency of the great magnet; and their magnetiſm is ſo diſpoſed, that their mutual attractions exceed their repulſions. Alſo, why an iron rod, placed nearly in the magnetical direction, will finally arrange itſelf in that direction. Alſo, why the terreſtrial polarity of common iron is indifferent, and either end of the rod will ſettle in the north, if it have nearly that poſition at firſt. The magnetiſm induced by mere momentary poſition is ſo feeble as to yield to any artificial magnetiſm. As a moment was ſufficient for imparting it, a moment ſuffices for deſtroying it; and another moment will impart the oppoſite magnetiſm. But artificial magnetiſm requires more force for its production, and ſome of it remains when the producing cauſe is removed, and it does not yield at once to the contrary magnetiſm. That there is no farther difference appears from this, that long continued poſition gives determined and permanent magnetiſm, and that it is deſtroyed by an equally long continuance in the contrary poſition. It ſeems to be very generally true, that a magnet will carry more by its north than by its ſouth pole. It ſhould be ſo in this part of the world, becauſe the terreſtrial magnetiſm induced on the iron conſpires with the magnetiſm induced by the north pole of a magnet, but counteracts the magnetiſm induced by the ſouth pole.

The propriety of Mr Savery's, Mr Canton's, and Mr Antheaume's proceſſes for beginning the impregnation of hard ſteel bars is now plain, and the ſuperior effect of the two great bars of common iron in the propoſed method of Mr Antheaume. We cannot but take this opportunity of paying the proper tribute of praiſe to the ingenuity of Mr Savery. Every circumſtance of his proceſs was ſelected in conſequence of an accurate conception of magnetiſm, and the combination of this ſcience with Dr Gilbert's theory. His proceſs is the ſame with Antheaume's in every reſpect, except the circumſtance of the double touch borrowed from Mitchell and Canton. Theſe obſervations do not detract from the diſcernment of Mitchell and Canton, who ſaw in thoſe experiments what had eſcaped the attention of hundreds of readers.

68
Seeming objection deduced from the want of ſenſible attraction.

But there occurs an objection to this theory of Dr Gilbert, which was urged againſt it with great force. We obſerve no tendency in the magnet or compaſs needle toward this ſuppoſed magnet. An iron or ſteel bar is not found to increaſe its tendency downwards, that is, is not ſenſibly heavier, when its ſouth pole is uppermoſt in this part of the world. A needle ſet afloat on a piece of cork arranges itſelf quickly in the proper direction; but if continued ever ſo long afloat, it has never been obſerved to approach the north ſide of the veſſel. This is quite unlike what we obſerve in the mutual actions of magnets, or the action of magnets on iron. This objection appears to have given Dr Gilbert ſome concern; and he mentions many experiments which have been tried on purpoſe to diſcover ſome magnetical tendency. He gets rid of it as well as he can, by ſaying, that the directive power of a magnet extends much farther than its attractive power. He confirms this by ſeveral experiments. But Dr Gilbert had not ſtudied the ſimultaneous actions of the four poles, nor explained, by the principles of compound motion, how theſe produced all the poſſible poſitions of the needle. Indeed, the compoſition of mechanical forces was by no means familiar with philoſophers at the end of the 16th century. We ſee it now very diſtinctly. The polarity of the needle, or the force with which it turns itſelf into the magnetical poſition, depends on the difference between the *ſums* of the actions of each pole of the magnet on both the poles of the needle; whereas its tendency towards the magnet depends on the difference of the *differences* of thoſe actions (ſee n° 22, 25.) The firſt may thus be very great when the other is almoſt inſenſible. We ſee, that coarſe iron filings heap about the magnet very faſt, and that very fine filings approach it very ſlowly. Now, the largeſt magnet that we can employ, when compared with the great magnet in the earth, is but as a particle of the fineſt filings that can be conceived. This ſurely diminiſhes exceedingly, if it does not entirely annihilate the objection: but as we have heard it urged by many as an improbable thing, that a long magnet, kept afloat for many months (which has been done) ſhall not ſhew the *ſmalleſt* tendency towards the pole of the terreſtrial magnet, we think it deſerves to be conſidered with accuracy, and the queſtion decided in a way which will admit of no doubt.

69 This completely anſwered.

Let the very ſmall magnet C (fig. 25.) be placed near a great magnet A, and then near a ſmaller magnet B, in ſuch a manner that its polarity to both ſhall be the ſame; and then let us determine the proportion between the attractions of A and B for the ſmall magnet C.

This will evidently depend on the law of magnetic action. For greater ſimplicity of inveſtigation, we ſhall content ourſelves with ſuppoſing the action to be inverſely as the diſtance.

Let AN, $= $AS, $= a$; BN $= b$; C$n = c$, AC $= d$, BC $= \delta$; and let the abſolute force of A be to that of B at the ſame diſtance as m to 1.

The magnetic action being ſuppoſed proportional to $\frac{1}{d}$, we have,

1. Action of AN on C$s = \frac{m}{d-a-c}$.

2. ——— AN on C$n = -\frac{m}{d-a+c}$.

3. ——— AS on C$s = -\frac{m}{d+a-c}$.

4. ——— AS on C$n = \frac{m}{d+a+c}$.

5. The whole action $= \frac{8macd}{\overline{d^2-\overline{a+c}^2}|^2 \times \overline{d^2-\overline{a-c}^2}|^2}$.

6. If c be very ſmall in compariſon with a or b, the whole action of A is very nearly $= \frac{8macd}{\overline{d^2-a^2}^2}$.

7. And the tendency of C to B is, in like manner, $= \frac{8bc\delta}{\overline{\delta^2-b^2}^2}$.

The directive powers of A and B are at their maximum ſtate when C is placed with its axis at right angles to the lines AC or BC. In which caſe we have,

8. The directive power of A $= \frac{4ma}{d^2-a^2}$.

9. The directive power of B $= \frac{4b}{\delta^2-b^2}$.

When theſe directive powers are made equal, by placing C at the proper diſtances from A and B, we have,

10. $4ma : 4b$, or $ma : b = d^2-a^2 : \delta^2-b^2$
And $ma\delta^2 - mab^2 = bd^2 - ba^2$
$ma\delta^2 = b(d^2-a^2) + mab^2$.

11. $\delta^2 = \frac{b}{ma}(d^2-a^2) + b^2$.

12. $\delta = \sqrt{\frac{b}{ma}(d^2-a^2) + b^2}$.

Let the attractions of A and B for the very ſmall magnet C, when its polarity to both is the ſame, be expreſſed by the ſymbols α and β. We have

$\alpha : \beta = \frac{8macd}{(d^2-a^2)^2} : \frac{8bc\delta}{(\delta^2-b^2)^2}$, which, by n° 10. is $= \frac{8(d^2-a^2)cd}{(d^2-a^2)^2} : \frac{8(\delta^2-b^2)c\delta}{(\delta^2-b^2)^2} = \frac{d}{d^2-a^2} : \frac{\delta}{\delta^2-b^2}$, $= bd : ma\delta$; that is,

13. Attr^n of A : attr^n of B $= bd : ma\delta$.

As an example of this compariſon, let us ſuppoſe the great terreſtrial magnet to be a thouſand times larger and ſtronger than the magnet whoſe attraction we are comparing with that of terreſtrial magnetiſm. Let us alſo ſuppoſe the diſtance from the pole of the great magnet to be ſmall, ſo that its attraction may be conſiderable. Let us make $d = 1200$, a being $= 1000$, and $b = 1$. Theſe are all very reaſonable ſuppoſitions. Subſtituting theſe values in the formula, we have attr^n of A : attr^n of B $= 1 : 1000$ very nearly; and therefore when the needle, when placed near a magnet, vibrates by its polarity as faſt as it does by natural magnetiſm, its tendency toward that magnet muſt be altogether inſenſible; for the diſproportion is incomparably greater than that of 1 to 1000, in the largeſt magnets with which we can make experiments. Obſerve alſo, that we have taken the caſe where the attractions are the ſtrongeſt, viz. when the magnet C is placed in the axis of A or B. In the oblique poſitions, tangents to the magnetic curves, the attractions are ſmaller, almoſt in any ratio.

We took the inverſe ratio of the diſtances for the law of action, only becauſe the analyſis was very ſimple. It is very evident, that the diſproportion will be ſtill more remarkable if the action be inverſely as the ſquare of the diſtance.

The objection therefore to the origin of the polarity of the compaſs needle, and of all other magnets, namely, the action of a great magnet contained in the earth, appears plainly to be of no force. We rather think that the want of all ſenſible attraction, where there is a briſk polarity, is a proof of the juſtneſs of the conjecture; for if the compaſs needle were arranged by the action of magnetic rocks, or even extenſive ſtrata, near the ſurface of the earth, the attractions would bear a greater proportion to the polarities. We have even obſerved this. A conſiderable maſs of magnetic ſtratum was found to derange the needle of a ſurveyor's theodolite at a conſiderable diſtance all around (about 140 yards). The writer placed the needle on a thin lath, which juſt floated it on water in a large wooden diſh, and ſet it in a place where it was drawn about 15 degrees from the magnetic meridian. It was left in that ſituation a whole night, well defended from the wind by a board laid on the diſh. Next morning it was found applied to that ſide of the diſh which was neareſt to the diſturbing rocks. It had moved about ſix inches. This was repeated three times, and each time it moved in the ſame direction (nearly), which differed conſiderably from the direction of the needle itſelf.

It is now plain that we may, with confidence, aſſume Dr Gilbert's theory of terreſtrial magnetiſm as ſufficiently eſtabliſhed. And, ſince we muſt certainly call that the north pole of the great magnet which is ſituated in the northern parts of the earth, and ſince thoſe poles of magnets which attract each other have oppoſite polarities, we muſt ſay, that what we call the north pole of a mariner's needle, or of any other magnet, has the ſouthern polarity.

We may now venture to go farther with Dr Gilbert, and

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The great magnet is the ſource of all natural magnetiſm.

and to ſay that *all* the magnetiſm which we obſerve, whether in nature or art, is either the immediate or the remote effect of the action of the great magnet. As ſoft bars ſoon acquire a tranſient magnetiſm; as hard bars, after long expoſure, acquire a ſenſible and permanent magnetiſm—we muſt infer, that ores of iron, which are in a ſtate fit for impregnation, muſt acquire a ſenſible and permanent magnetiſm, by continuing, for a ſeries of ages, in the bowels of the earth. And thus the magnetiſm of loadſtones, which, till the diſcovery of the natural magnetiſm acquired by poſition, were the ſources of all our magnetical phenomena, is now proved to be a neceſſary conſequence of the exiſtence and agency of a great magnet contained in the bowels of the earth.

71
Loadſtones in the mine may have their poles in any poſition.

It ſeems to reſult from this theory, that, in theſe northern parts of the world, that part of every natural loadſtone that is at the extremity of the line drawn through the ſtone in the magnetic direction ſhould be its pole; and that the loadſtone, when properly poiſed, ſhould of itſelf aſſume the very poſition which it had in the mine. Dr Gilbert complains of the inattention of miners (*rude hominum genus, lucro potius quam phyſicæ conſulentes*) to this important circumſtance. Once, however, he had the good fortune to be advertiſed of a great magnetic maſs lying in its matrix. He repaired quickly to the mine, examined it, and marked its points which were in the extremities of the magnetic line. When it was detached from its matrix, he had the pleaſure of finding its poles in the very places he expected. The loadſtone was of conſiderable ſize, weighing about 20 pounds.—Mr Wilcke gives in the Swediſh Commentaries ſeveral inſtances of the ſame kind.

But ſhould this always be the caſe? By no means. There are many circumſtances which may give the magnetiſm of a loadſtone a very different direction. We have found, that ſimple juxtapoſition to a magnet will ſometimes give a ſucceſſion of poles to a long bar of hard ſteel. The ſame thing may happen to an extenſive vein of magnetiſable matter. The loadſtone taken out of this vein may have been placed like that of a ſoft bar placed in the magnetic line, if lying in one part of the vein; if taken from another part of it, its polarity may be the very reverſe; and in another part it may have no magnetiſm, although completely fitted for acquiring it. It may have its poles placed in a direction different from all theſe, in conſequence of the vicinity of a greater loadſtone. As loadſtones poſſeſſed of vigorous magnetiſm are always found only in ſmall pieces, and in pieces of various ſizes and force, we muſt expect every poſition of their poles. The only thing that we can expect by theory is, that adjoining loadſtones will have their friendly poles turned toward each other, and a general prevalence of or tendency to a polarity ſymmetrical with that of the earth. The reader will find ſome more obſervations to this purpoſe in the article VARIATION, *Encycl.* p. 623. as alſo in Gilbert's treatiſe, B. III. c. 2. p. 121.

Nor ſhould all ſtrata or maſſes of iron ore be magnetical. We know that none are ſuſceptible of induced magnetiſm, but ſuch as are, to a certain degree, in the metallic ſtate. Such ores are not abundant. Nay, even all of ſuch ſtrata do not neceſſarily acquire magnetiſm by the action of the great magnet. If their principal dimenſions lie nearly perpendicular to the magnetic direction, they will not acquire any ſenſible quantity. A ſtratum in this country, riſing about 17 degrees to the N. N. W. will ſcarcely acquire magnetiſm. It may alſo happen, that the influence of the great magnet is counteracted by that of ſome extenſive ſtratum inacceſſible to man, by reaſon of its great depth.

72
Probable cauſe of their great natural vigour.

Thus we ſee, that all the appearances of the original magnetiſm of loadſtones are perfectly conſiſtent with the notion that they are effects of one general coſmical cauſe, the action of the great magnet contained in the earth, and that there is no occaſion to ſuppoſe this great magnet to differ, in its conſtitution or manner of action, from the ſmall maſſes of ſimilar matter called loadſtone. The only difficulty that preſents itſelf is the great ſuperiority of magnetic force obſervable in ſome loadſtones over other maſſes of ores circumjacent, which are not diſtinguiſhable by us by any other circumſtance. We acknowledge ourſelves unable to ſolve this difficulty; for the magnetiſm of ſuch pieces is ſometimes incomparably ſtronger than what a bar of iron acquires by poſition; yet this bar is much more ſuſceptible than the ores which are fit for becoming loadſtones. Perhaps there is ſome chemical change which obtains gradually in certain maſſes, which aids the impregnation, in the ſame way that we know that being red hot deſtroys all magnetiſm, whether in a metal bar or in an ore. This ſeems to be confirmed by what we ſee in ſome old iron ſtanchions, which acquire the ſtrongeſt magnetiſm in thoſe parts of their ſubſtance which are combining themſelves with ingredients floating in the atmoſphere. That part which is caſed in the ſtone, and exfoliates and ſplits with ruſt, being converted into ſomething like what is called finery cinder, becomes highly and permanently magnetic. Such peculiarities as theſe, operating for ages, may allow a degree of magnetical impregnation (in whatever this may conſiſt) to take place, to which we can ſee no reſemblance in our experiments. It would be worth while to place iron wires in a tube in the magnetic direction, which could be kept of a proper red heat, while it is converted into æthiops by ſteam. It is not unlikely that it would acquire a ſenſible and permanent magnetiſm in this way. It may be, that the little atoms, as they arrange themſelves in a ſort of cryſtalline or ſymmetrical form, may alſo arrange ſo as to favour magnetiſm. Were this tried in the vicinity of a ſtrong magnet, the effect might be more remarkable and preciſe. Perhaps, too, while iron is precipitated in a metallic form from its ſolutions by another metal, ſomething of the ſame kind may happen. We know, that proper ores of iron, expoſed to cementation in a low red heat, in the magnetic direction, becomes magnetic.

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Natural cauſes of the changes of the magnetic direction.

Notice has been taken in the *Encycl.* art. VARIATION, of the attempts of ingenious men to explain the change which is obſerved in all parts of the globe, on the direction of the mariner's needle, the gradual change of the variation. The hypotheſis of Dr Halley, that the globe which we inhabit is hollow, and incloſes a magnetic nucleus, moving round another axis, is not inconſiſtent with any natural law, if he did not ſuppoſe the interval filled up with ſome fluid. The action of the nucleus and ſhell on the intervening fluid would gradually bring the two to one common motion of rotation, as may be inferred from the reaſonings employed by Newton in his remarks on the Carteſian vortices.

Leaving out this circumſtance, there is only another cauſe which can affect, and muſt affect, the rotation of both; namely, the mutual action of the magnetic nucleus, and the maſſes of magnetic matter in the ſhell. If the axis of rotation of this nucleus be different from the line joining its magnetic poles, theſe poles will have a motion relative to the ſhell; and this motion may eaſily be conceived ſuch as will produce the changes of magnetic direction which we obſerve. It may even produce a motion of the northern magnetic pole in one direction, and of the ſouthern pole in the oppoſite direction, and this with the appearance of different periods of rotation, as ſuppoſed by Mr Churchman. We may here obſerve, by the way, that the change of magnetic direction in this country is not nearly ſo great as is commonly imagined. The horizontal needle has ſhifted its poſition about 35° at London ſince 1585; but the point of the dipping needle has not changed 10°. We may alſo obſerve, that when the pole of the central magnet changes its place, the magnetiſm of an extenſive ſtratum, influenced by it, may ſo alter its diſpoſition, as to change the poſition of the compaſs needle in the oppoſite direction to that of the change which the central magnet alone would induce on it.

But as motions have not yet been aſſigned to this nucleus, which quadrate with the obſerved poſitions of the needle, and as the very exiſtence of it is hypothetical, it may not be amiſs to examine, whether ſuch a change of variation may not be explained by what we know of the laws of magnetiſm, and of the internal conſtitution of this earth?

1. It is pretty certain, that the veins in which loadſtones are found are not parts of the great magnet. This appears from their having two poles while in the mine, and alſo from the very ſmall depth to which man has been able to penetrate. When we compare the poſitions of the dipping needle with thoſe of a ſmall needle near a magnet, we muſt infer, that the poles are very far below the ſurface.

Yet we know, that there are magnetiſable ſtrata of very great extent occupying a very conſiderable portion of the external covering. Though their bulk and abſolute power may be ſmall, when compared with thoſe of the great magnet, yet their greater vicinity to the needles on which obſervations are made, may give them a very ſenſible influence. In this way may a great deal of the obſerved irregularities of the poſitions of the needle be accounted for. In the Lagoon at Teneriffe, *Feuillée* obſerved the variation 13° 30′ weſt in 1724, while at the head of the iſland it was only 5°. The dip at the Lagoon was 63° 30′, greatly ſurpaſſing what was obſerved in the neighbourhood. Muller found, in the mountains of Bohemia, great and deſultory differences of declination, amounting ſometimes to 50°. At Mantua, the variation in 1758 was 12°; while at Bononia and Brixia it was nearly 18°. Great irregularities were obſerved by Goëte in the Gulph of Finland, eſpecially near the iſland of Suſſari, among ſome rocks: on one of theſe, the needle ſhewed no polarity. Captain Cook and Captain Phipps obſerved differences of 10°, extending to a conſiderable diſtance, on the weſt coaſts of North America. In the neighbourhood of the iſland Elba in the Mediterranean, the poſition of the needle is greatly affected by the iron ſtrata, in which that iſland ſo much abounds. In this country, there are alſo obſerved ſmall deviations, which extend over conſiderable tracts of country, indicating a great extent of ſtrata that are weakly magnetic. Since ſuch ſtrata receive their magnetiſm by induction, in a manner ſimilar to a bar of hard ſteel, and ſince we know that this receives it gradually, it may very probably happen, that a long ſeries of years may elapſe before the magnetiſm attains its ultimate diſpoſition.

Here, then, is a neceſſary change of the magnetic direction; and although it may be very different in different places, according to the diſpoſition and the power of thoſe ſtrata, there muſt be a general vergency of it one way.

2. It is well known that all metals, and particularly iron, are in a progreſs of continual production and demetallization. The veins of metals, and more particularly thoſe of iron, are evidently of poſterior date to that of the rocks in which they are lodged. Chemiſtry teaches us, by the very nature of the ſubſtances which compoſe them, that they are in a ſtate of continual change. This is another cauſe of change in the magnetic direction. Nay, we know that ſome of them have ſuddenly changed their ſituation by earthquakes and volcanoes. Some of the ſtreams of lava from Veſuvius and Ætna abound in iron. This has greatly changed its ſituation; and if the ſtrata from which it proceeded were magnetical, the needle in its neighbourhood muſt be affected. Nay, ſubterranean heat alone will effect a change, by changing the magnetiſm of the ſtrata. Mr Lievog, royal aſtronomer at Beſſeſtedt in Iceland, writes, that the great eruption from Hecla in 1783, changed the direction of the needle nine degrees in the immediate neighbourhood. This change was produced at a mile's diſtance from the frozen lava; and it diminiſhed to two degrees at the diſtance of 2½ miles. He could not approach any nearer, on account of the heat ſtill remaining in the lava, after an interval of 14 months.

All theſe cauſes of change in the direction of the mariner's needle muſt be partial and irregular. But there is another cauſe, which is coſmical and univerſal. Dr Halley's ſuppoſition of four poles, or, at leaſt, the ſuppoſition of irregular and diffuſed poles, ſeems the only thing that will agree with the obſervations of declination. We know that all magnetiſm of this kind (that is, diſpoſed in this manner) has a natural tendency to change. The two northern poles may have the ſame or oppoſite polarities. If they are the ſame, their action on each other tends to diminiſh the general magnetiſm, and to cauſe the centre of effort to approach the centre of the magnet. If they have oppoſite polarities, the contrary effect will be produced. The general magnetiſm of each will increaſe, and the pole (or its centre of effort) will approach to the ſurface. In either of theſe caſes, the compound magnetiſm of the whole may change exceedingly, by a change by no means conſiderable in the magnetiſm of each pair of poles. It is difficult to ſubject this to calculation; but the reader may have very convincing proof of it, by taking a ſtrong and a weaker magnet of the ſame length, and one of them, at leaſt, of ſteel not harder than ſpring temper. Lay them acroſs each other like an acute letter X; and then place a compaſs needle, ſo that its plane of rotation may be perpendicular to the plane of the X. Note exactly the poſition in which the needle ſettles. In a few minutes after, it will be found to change conſiderably, although no remarkable change has yet happened to the magnets themſelves.

74 Speculations about the origin of magnetiſm. Hypotheſis of Æpinus.

WE flatter ourſelves, that our readers will grant that the preceding pages contain what may juſtly be called a theory of magnetiſm, in as much as we have been able to include every phenomenon in one general fact, the induction of magnetiſm; and have given ſuch a deſcription of that fact and its modifications, that we can accurately predict what will be the appearances of magnets and iron put into any deſired ſituation with reſpect to each other. If our notions of philoſophical diſquiſition (delivered in art. PHILOSOPHY, *Encycl. Brit.*) be juſt, we have explained the ſubordinate phenomena, or have given a theory of magnetiſm.

But it is not eaſy to ſatiſfy human curioſity. Men have even inveſtigated, or ſought for cauſes of the perſeverance of matter in its preſent condition. We have not been contented with Newton's theory of the celeſtial motions, and have ſought for the cauſe of that mutual tendency which he called gravitation, and of which all the motions are particular inſtances.

Philoſophers have been no leſs inquiſitive after what may be the cauſe of that mutual attraction of the diſſimilar poles, and the repulſion of the ſimilar poles, and that faculty of mutual impregnation, or excitement, which ſo remarkably diſtinguiſh iron, in its various ſtates, from all other ſubſtances. The action of bodies on each other at a diſtance, has appeared to them an abſurdity, and all have had recourſe to ſome material intermedium. The phenomenon of the arrangement of iron filings is extremely curious, and naturally engages the attention. It is hardly poſſible to look at it without the thought ariſing in the mind of a ſtream iſſuing from one pole of the magnet, moving round it, entering by the other pole, and again iſſuing from the former outlet. Accordingly, this notion has been entertained from the earlieſt times, and different ſpeculatiſts have had different ways of conceving how this ſtream operated the effects which we obſerve.

The ſimpleſt and moſt obvious was juſt to make it act like any other ſtream of fluid matter, by impulſion. Impulſion is the thing aimed at by all the ſpeculatiſts. They have a notion, that we conceive this way of communicating motion with intuitive clearneſs, and that a thing is fully explained when it can be ſhewn that it is a caſe of impulſion. We have conſidered the authority of theſe explanations in the article IMPULSION of this *Supplement*, and need not repeat our reaſons for refuſing it any pre-eminence. But even when we have ſhewn the phenomena to be caſes of impulſion by ſuch a ſtream, the greateſt difficulty, the moſt curious and the moſt embarraſſing, is to aſcertain the ſources of this impulſive motion of the fluid—How, and from what cauſe does it begin? What forces bend it in curves round the magnet? Thoſe philoſophers, whoſe principle obliges them to explain gravitation alſo by impulſe, muſt have another ſtream to impel this into its curves. Acting by impulſion, this magnetic ſtream muſt loſe a quantity of motion equal to what it communicates. What is to reſtore this? What directs it in a particular courſe thro' the magnet? And what is it that can totally alter that courſe—in a moment—in all the phenomena of induced magnetiſm? How does it impel? Lucretius, either of himſelf, or ſpeaking after the Greek philoſophers, makes it impel, not the iron, but the ſurrounding air, ſweeping it out of the way; and thus giving occaſion for the ſurrounding air to ruſh around the magnet, and to hurry the bits of iron toward it. There is, perhaps, more ingenious refinement in this thought than in any of the impulſive theories adopted ſince his day by Des Cartes, Euler, and other great philoſophers: But it is ſagaciouſly remarked by D. Gregory, in his MS. notes on Newton, that this theory of Lucretius falls to the ground; becauſe the experiments ſucceed juſt as well under water as in the air. As to the explanations, or deſcriptions, of the canals and their dock gates, opening in one direction, and ſhutting in the other, conſtructions that are changed in an inſtant in a bar of iron, by changing the poſition of the magnet, we only wonder that men, who have a reputation to loſe, ſhould ever hazard ſuch crude and unmechanical dreams before the public eye. The mind of man cannot conceive the poſſibility of their formation; and if they are really formed, the effects ſhould be the very oppoſite of thoſe that are obſerved: the ſtream ſhould move thoſe bodies leaſt which afford ready channels for its paſſage. If a rag of iron filings be arranged by the impulſion of ſuch a ſtream, it ſhould be carried along by it; and if it is *impelled toward* one end of the magnet, it ſhould be impelled *from* the other end. Since we now know, that each particle of filings is a momentary magnet, we muſt allow a ſimilar ſtream whirling round each. Is that an explanation which exceeds all power of conception?

But has it ever been ſhewn, that there is any impulſion at all in theſe phenomena? Where is the impelling ſubſtance? The only argument ever offered for its exiſtence is, that we are reſolved that the phenomena of magnetiſm ſhall be produced by impulſion, and the arrangement of iron filings looks ſomewhat like a ſtream. But enough of this. We truſt that we have ſhewn the way in which this arrangement obtains in the cleareſt manner. Every particle becomes magnetic by induction. This is a fact, which ſets all reaſoning at defiance. The polarity of each rag is ſo diſpoſed, that their adjoining ends turn to each other. This is another uncontrovertible fact. And theſe two facts explain the whole. The arrangement of iron filings, therefore, is a ſecondary fact, depending on principles more general; and therefore cannot, conſiſtently with juſt logic, be aſſumed as the foundation of a theory.

Had magnetiſm exhibited no phenomena beſides the attraction and repulſion of magnets, it is likely that we ſhould not have proceeded very far in our theories, and would have contented ourſelves with reducing theſe phenomena to their moſt general laws. But the communication of magnetiſm ſeems a great myſtery. The ſimple approach of a magnet communicates theſe powers to a piece of iron; and this without any diminution of its own powers. On the contrary, beginning with magnets which have hardly any ſenſible power, we can, by a proper alternation of the manipulations, communicate the ſtrongeſt magnetiſm to as many hard ſteel bars as we pleaſe; and the original magnets ſhall be brought to their higheſt degree of magnetiſm. We have no notion of powers or faculties, but as qualities of ſome ſubſtances in which they are inherent. Yet here is no appearance of ſomething abſtracted from one body, and communicated to, or ſhared with another. The proceſs is like kindling a great fire by a ſimple ſpark; here is no communication, but only *occaſion* given to the exertion of powers inherent in the combuſtible matter. It appears probable, that the caſe is the ſame in magnetiſm; and that all that is performed in making a magnet is the excitement of powers already in the ſteel, or the giving occaſion for their exertion; as burning the thread which ties together the two ends of a bow, allows it to unbend. This notion did not eſcape the ſagacity of Dr Gilbert; and he is at much pains to ſhew, that the *coitio magnetica* is a quality inherent in all magnetical bodies, and only requires the proper circumſtance for its exertion. He is not very fortunate in his attempts to explain *how* it is developed by the vicinity of a magnet, and how this faculty, or actual exertion of this power, becomes permanent in one body, while in another it requires the conſtant preſence of the magnet.

74 Magnetical hypotheſis of Æpinus.

It is to Mr Æpinus, of the Imperial Academy of St Peterſburgh, that we are indebted for the firſt really philoſophical attempt to explain all theſe myſteries. We mentioned, in the article ELECTRICITY, *Suppl.* the circumſtance which ſuggeſted the firſt hint of this theory to Æpinus, *viz.* the reſemblance between the attractions and repulſions of the tourmaline and of a magnet. A material cauſe of the electric phenomena had long been thought familiar to the philoſophers. They had attributed them to a fluid which they called an electric fluid, and which they conceived to be ſhared among bodies in different proportions, and to be tranſferable from one to another. Dr Franklin's theory of the Leyden phial, which led him to think that the faculty of producing the electrical phenomena depended on the deficiency as well as the redundancy of this fluid, combined with the phenomena of induced electricity, ſuggeſted to Æpinus a very perſpicuous method of ſtating the analogy of the tourmaline and the magnet; which he publiſhed in 1758 in a paper read to the academy.

Reflecting more deeply on theſe things, Mr Æpinus came by degrees to perceive the perfect ſimilarity between all the phenomena of electricity by poſition and thoſe of magnetiſm; and this led him to account for them in the ſame manner. As the phenomena of the Leyden phial, explained in Franklin's manner, ſhews that a body may appear electrical all over, by having leſs than its natural quantity of the electric fluid, as well as by having more, it ſeemed to follow, that it may alſo be ſo in reſpect to different parts of the ſame body; and therefore a body may become electrified in oppoſite ways at its two extremities, merely by abſtracting the fluid from one end, and condenſing it in the other; and thus may be explained the phenomena of induced electricity, where nothing appears to have been communicated from one body to the other. If this be the caſe, the two ends of a body rendered electric by induction ſhould exhibit the ſame diſtinctions of phenomena that are exhibited by bodies wholly redundant and wholly deficient. The redundant ends ſhould repel each other; ſo ſhould the deficient ends; and a redundant part ſhould attract a deficient. All theſe reſults of the conjecture tally exactly with obſervation, and give a high degree of probability to the conjecture. The ſimilarity of theſe phenomena to the attractions of the diſſimilar poles of a magnet, and the repulſions of the ſimilar poles, is ſo ſtriking, that the ſame mode of explanation forces itſelf on the mind, and led Mr Æpinus to think, that the faculty of producing the magnetical phenomena belonged to a magnetical fluid, reſiding in all bodies ſuſceptible of magnetiſm; and that the exertion of this faculty require nothing but the abſtraction of the fluid from one end of the magnetic bar, and its conſtipation in the other. And this conjecture was confirmed by obſerving, that in the induction of magnetiſm on a piece of iron, the power of the magnet is not diminiſhed.

All theſe circumſtances led Mr Æpinus to frame the following hypotheſis:

1. There exiſts a ſubſtance in all magnetic bodies, which may be called the magnetic fluid; the particles of which repel each other with a force decreaſing as the diſtance increaſes.
2. The particles of magnetic fluid attract, and are attracted by the particles of iron, with a force that varies according to the ſame law.
3. The particles of iron repel each other according to the ſame law.
4. The magnetic fluid moves, without any conſiderable obſtruction, through the pores of iron and ſoft ſteel; but is more and more obſtructed in its motion as the ſteel is tempered harder; and in hard tempered ſteel, and in the ores of iron, it is moved with the greateſt difficulty.

In conſequence of this ſuppoſed attraction for iron, the fluid may be contained in it in a certain determinate quantity. This quantity will be ſuch, that the accumulated attraction of a particle for all the iron balances, or is equal to, the repulſion of all the fluid which the iron contains. The quantity of fluid competent to a particle of iron is ſuppoſed to be ſuch, that the repulſion exerted between it and the fluid competent to another particle of iron is alſo equal to its attraction for that particle of iron: And therefore the attraction between the fluid in an iron bar A for the iron of another bar B, is juſt equal to its repulſion for the fluid in B; it is alſo equal to the repulſion of the iron in A for the iron in B. This quantity of fluid reſiding in the iron may be called its NATURAL QUANTITY.

In conſequence of the mobility through the pores of the iron, the magnetic fluid may be abſtracted from one end of a bar, and condenſed in the other, by the agency of a proper external force. But this is a violent ſtate. The mutual repulſion of the particles of condenſed fluid, and the attraction of the iron which it has quitted, tend to produce a more uniform diſtribution. If we reflect on the law of action, we ſhall clearly perceive, that ſomewhat of this tendency muſt obtain in every ſtate of condenſation and rarefaction, and that there can be a perfect equilibrium only when the fluid is diffuſed with perfect uniformity. This, therefore, may be called the NATURAL STATE of the iron.

If the reſiſtance oppoſed by the iron to the motion of the magnetic fluid be like that of perfect fluids to the motion of ſolid bodies, ariſing entirely from the communication of motion, there is no tendency to uniform diffuſion ſo weak as not to overcome ſuch reſiſtance, and finally to produce this uniform diſtribution. But (as is more probable) if the obſtruction reſembles that of a clammy fluid, or of a ſoft plaſtic body like clay, ſome of the accumulation, produced by the agency of an external force, may remain when the force is removed; the diffuſion will ceaſe whenever the equaliſing force is juſt in equilibrio with the obſtruction.

All the preceding circumſtances of the hypotheſis are ſo perfectly analogous to the hypotheſis of Mr Æpinus for explaining the electrical phenomena, which is given in detail in the article Electricity of this *Supplement*, that it would be ſuperfluous to enter into a minute diſcuſſion of their immediate reſults. We therefore beg the reader to peruſe that part of the article Electricity where the elements of Æpinus's hypotheſis are delivered, and the phenomena of induced electricity explained (*viz.* from n° 11. to 60. incluſive), and to ſuppoſe the diſcourſe to relate to the *magnetical* fluid. Let N, S, *n*, *s*, be conſidered as the overcharged and undercharged parts of a magnetical body, or the poles of a magnet, and of iron rendered magnetical by induction. We ſhall confine our obſervations in this place to thoſe circumſtances in which the mechanical phenomena of magnetiſm are limited by the circumſtance, that magnets always contain their natural quantity of fluid; ſo that their action on iron, and on each other, depends entirely on its unequable diſtribution; as is the caſe with induced electricity.

75 Magnetiſm how induced on iron by juxtapoſition.

Let the magnet NAS (fig. 26.), having its north pole NA overcharged, be ſet near to the bar *n* B *s* of common iron, and let their axes form one ſtraight line. Then (as in the caſe of electrics) the overcharged pole NA acts on the bar B only by means of the redundant fluid which it contains. For that portion of its fluid, which is juſt ſufficient for ſaturating the iron, will repel the fluid in B, juſt as much as the iron in NA attracts it; and therefore the fluid in B ſuſtains no change from this portion of the fluid in NA. In like manner, the pole SA acts on B only in conſequence of the iron in SA, which is not ſaturated or attended by its equivalent fluid.

If the fluid in B is immoveable, even the redundant fluid in NA, and redundant iron in SA, will produce no *ſenſible* effect on it: For every particle of iron in B is accompanied by as much fluid as will balance, by its repulſions and attractions, the attractions and repulſions of the equidiſtant particle of iron. But as the magnetical fluid in B is ſuppoſed to be eaſily moveable, it will be repelled by the redundant fluid in AN toward the remote extremity *n*, till the reſiſtance that it meets with, joined to its own tendency to uniform diffuſion, juſt balances the repulſion of AN. This tendency to uniform diffuſion obtains as ſoon as any fluid quits its place; as has been ſufficiently explained in the Supplementary article Electricity, n° 16. 17. &c.)

But, at the ſame time, the redundant iron in AS attracts the fluid in B, and would abſtract it from B *n*, and condenſe it into B *s*. This attraction oppoſes the repulſion now mentioned. But, becauſe AS is more remote from every point of B than AN is from the ſame point, the repulſions of the redundant fluid in AN will prevail; and, on the whole, fluid will be propelled toward *n*, and will be rarefied on the part B *s*. But as to what will be the law of diſtribution, both in the redundant and deficient parts of B, it is plain that nothing can be ſaid with preciſion. This muſt depend on the diſtribution of the fluid in the magnet NAS. The more diffuſed that we ſuppoſe the redundant fluid and matter in the magnet, the farther removed will the centres of effort of its poles be from their extremities; the ſmaller will be the action of AN and AS, the ſmaller will be their difference of action; and therefore the ſmaller will be the condenſation in B *n*, and the rarefaction in B *s*. Hence we learn, in the outſet of this attempt to explanation, that the action of a magnet will be ſo much the greater as its poles are more concentrated. This is agreeable to obſervation, and gives ſome credit to the hypotheſis. We can juſt ſee, in a very general manner, that the fluid will be rarer than its natural ſtate in *s*, and denſer in *n*; and that the change of denſity is gradual, and that the denſity may be repreſented by the ordinates of ſome line *c b d* (fig. 27.), while the natural denſity is repreſented by the ordinates to the line C *b* D, parallel to *s n*. There will be ſome point B of the iron bar, where the fluid will be of its natural denſity, and the ordinate B *b* will meet the line *c b d* in the point of its interſection with CD.

All this action is internal and imperceptible. Let us inquire what will be the *ſenſible* external action. There is a ſuperiority of attraction towards the magnet: For ſince the magnetic action is ſuppoſed to diminiſh continually by an increaſe of diſtance, the curve, whoſe ordinates repreſent the forces, has its convexity toward the axis. Alſo, the force of the poles AN, AS are equal at equal diſtances: For, by the hypotheſis, the attraction and repulſion of an individual particle are equal at equal diſtances; and the condenſation in AN is equal to the deficiency in AS, by the ſame hypotheſis; becauſe NAS ſtill contains its natural quantity of fluid. Therefore the action of both poles may be expreſſed by the ordinates of the ſame curve, and they will differ only by reaſon of their diſtances. We may therefore expreſs the actions by the four ordinates Mm, Pp, Nn, Qq, of fig. 2.; of which the property (deduced from the ſingle circumſtance of its being convex toward the axis) is, that $Mm + Qq$ is greater than $Pp + Nn$. There is therefore a ſurplus of attraction. It is only this ſurplus that is perceived. The fluid, moveable in B, but retained by it ſo as not to be allowed to eſcape, is preſſed towards its remote end *n* by the exceſs $Pp — Qq$ of the repulſion of the redundant fluid in AN, above the attraction of the redundant iron in AS. This exceſs on every particle of the fluid is tranſmitted, by the common laws of hydroſtatics, to the ſtratum immediately incumbent on the extremity *n*, and B is thus preſſed away from A. But every particle of the ſolid matter in B is attracted towards A by the exceſs $Mm — Nn$ of the attraction of the redundant fluid in AN above the repulſion of the redundant iron in AS: and this exceſs is greater than the other; for $\overline{m + q}$ is greater than $\overline{p + n}$.

The piece of common iron *n* B *s* is therefore attracted, *in conſequence* of the fluid in it having been propelled towards its remote extremity, and diſtributed in a manner ſomewhat reſembling its diſtribution in NAS. Now, in this hypotheſis, magnetiſm is held to depend entirely on the diſtribution of the fluid. B has therefore become a magnet, has magnetiſm induced on it, and, only in conſequence of this induction, is attracted by A.

Had we ſuppoſed the deficient, or ſouth pole of A, to have been neareſt to B, the redundant matter in AN would have attracted the moveable fluid in B more than the remoter redundant fluid in AS repels it; and, on this account, the magnetic fluid would have been conſtipated in B *s*, and rarefied in B *n*. It would, in this caſe alſo, have been diſtributed in a manner ſimilar to its ſituation in the magnet. And B would therefore have been a momentary magnet, having its redundant pole fronting the deficient or diſſimilar pole of A. It is plain, that there would be the ſame ſurplus of attraction in this as in the former inſtance, and B would (on the whole) be attracted in conſequence, and only in conſequence, of having had a properly diſpoſed magnetiſm induced on it by juxtapoſition. The ſenſible attraction, in this caſe, is a *conſequence* of the diſtribution now deſcribed; becauſe, ſince the fluid conſtipated in the end next to A cannot quit B, the tendency of this fluid toward A muſt preſs the ſolid matter of B in this direction (by hydroſtatical laws) more than this ſolid matter is repelled in the oppoſite direction.

Thus it appears, that the hypotheſis tallies preciſely with the induction of magnetiſm. We do not call this an explanation of the phenomenon; for the fact is, that it is the hypotheſis that is explained by the phenomenon: That is, if any perſon be told that induced magnetiſm is produced by the action of a fluid, in conſequence of its ſituation being changed, he will find, that in order to agree with the attraction of diſſimilar, and the repulſion of ſimilar poles, he muſt accommodate the fluid to the phenomena, by giving it the properties aſſigned to it by Æpinus.

76 Conformity of the hypotheſis with a vaſt variety of phenomena.

But the agreement with this ſimpleſt poſſible caſe of the moſt ſimple example of induced magnetiſm, is not enough to make us adopt the hypotheſis as adequate to the explanation of all the magnetic phenomena. We muſt confront the hypotheſis with a variety of obſervations, to ſee whether the coincidence will be without exception.

When the key CB, in fig. 8. is brought below the conſtipated north pole N of the magnet SAN, its own moveable fluid is propelled from C towards B, and is diſpoſed in CB nearly after the ſame manner as in SAN. Therefore the redundant fluid in the lower end of the key repels the moveable fluid in the wire BD more than the redundant matter in the upper end C attracts it; and thus the fluid is rarefied in the upper end of the wire BD, and condenſed in its lower end D. CB and BD therefore are two temporary magnets, having their diſſimilar poles in contact, or neareſt to each other. This is all that is required for their attraction. This effect is promoted by the action of N on the wire BD, alſo propelling the fluid toward D; and thus increaſing the mutual attraction of CB and BD. In like manner, when the key CB is held above the magnet, the moveable fluid in it is more attracted by the redundant matter in SA than it is repelled by the more remote redundant fluid in AN. The ſame thing happens to the fluid in the wire BD. Therefore CB and BD muſt attract each other; and the key will carry the wire, although the magnet is below it, and alſo attracts it. This ſingularity proceeds from the almoſt perfect mobility of the fluid in the two pieces of common iron, which renders their poles extremely conſtipated; whereas the hardneſs required for the fixed magnetiſm of the magnet prevents this complete conſtipation and rarefaction. This can be ſtrictly demonſtrated in the caſe of ſlender rods of iron; but we can ſhew, and experience confirms it, that in other caſes, depending on the ſhape and the temper of the pieces, the wire will not adhere to the key, but to the magnet.

In the various ſituations and poſitions of the key and wire repreſented in fig. 7. the actions of ſome of the poles on the moveable fluid in the iron are oblique in regard to the length of the pieces; but, ſince the moveable matter is ſuppoſed to be a fluid, it will ſtill be propelled along the pieces, notwithſtanding their obliquity, in the ſame manner as gravity makes water occupy the lower end of a pipe lying obliquely. If indeed the magnetic fluid could eſcape from the iron without any obſtruction by the propulſion of the magnet, it could produce no attraction, or ſenſible motion, any more than light does in a tranſparent body. What is demonſtrated of the electric fluid in the Supplemental article ELECTRICITY, n° 133. is equally true here. Why the fluid does not eſcape when it is ſo perfectly moveable, is a queſtion of another kind, and will be conſidered afterwards; at preſent, the *hypotheſis* is, that it does not eſcape.

If the key and wire have the poſition fig. 10. n° 1. the fluid is expelled from the parts in contact, and is condenſed in the remote ends. So far from attracting each other, the key and wire muſt repel. They are temporary magnets, having their ſimilar poles fronting each other. They muſt repel each other, if preſented in a ſimilar manner to the ſouth pole of the magnet.

If they be preſented as in n° 2. fig. 10. where the actions of both poles of the magnet are equal, the ſtate of the fluid in them will not be affected. The redundant pole of the magnet repels the moveable fluid in both the key and the wire toward the upper ends; but the deficient pole acts equally on it in the oppoſite direction. It therefore remains uniformly diſtributed through their ſubſtance; and therefore they can exhibit no appearance of magnetiſm.

But if the key and wire be preſented to the *ſame* part of the magnet, but in another poſition, as ſhewn in fig. 8. n° 3. the fluid of the key will be abſtracted from C, and condenſed in B, by the joint action of both poles of the magnet. The ſame thing will happen in the wire BD. Here, therefore, we have two magnets with their diſſimilar poles touching. They will attract each other ſtrongly; and if carried gradually toward the upper or lower end of the magnet, they will ſeparate before the point B arrives abreaſt of N or S. For ſimilar reaſons, the pieces of iron preſented to the middle of the magnet, as in fig. 10. will have one ſide a weak north pole, and the other ſide a weak ſouth pole; but this will not be conſpicuous, unleſs the pieces be broad.

This experiment ſhews, in a very perſpicuous manner, the competency of the hypotheſis to the explanation of the phenomena. When the fluid is not moved, magnetiſm is not induced, even on the moſt ſuſceptible ſubſtance.

When a piece of iron A (fig. 10.), nearly as large as the magnet can carry, hangs at either pole, a large piece of iron B, brought near to the pole on the other ſide, ſhould cauſe it immediately to fall. If S be the deficient pole, it cauſes the fluid in A to aſcend to the top, and A is attracted: but, for the ſame reaſon, it cauſes the fluid in B to accumulate in its lower end. This redundant fluid muſt evidently counteract the redundant matter in S, in the induction of the magnetic ſtate on A. Being more remote from A than S is, it cannot wholly prevent the accumulation in the upper end of A; but it renders it ſo trifling, that the remaining attraction thence ariſing cannot ſupport the weight of A. This is a very inſtructive experiment.

But if, on the contrary, we bring a large piece of iron C below the heavy key A, this piece C will have its fluid accumulated in its upper end, both by the action of A on it, and by the action of the magnet. The attraction of the magnet for A ſhould therefore be augmented; and a magnet ſhould carry a heavier lump of iron when a great lump is beyond it. And it is clear (we think), for ſimilar reaſons, that the magnetiſm of the magnet itſelf in fig. 11. ſhould be increaſed by bringing a great lump of iron near its oppoſite pole: for the magnet differs from common iron only in the *degree* of the mobility of its fluid.

When a compaſs needle is placed oppoſite to the redundant pole N of a magnet AN (fig. 28.), it arranges itſelf magnetically. If a piece of common iron be now preſented laterally to the near point of the needle, the redundant matter in the adjoining parts of the needle and the iron ſhould make them repel; but if preſented to the remote end, the redundant matter in the iron ſhould attract the redundant fluid in that end of the needle, and that end ſhould turn toward the iron.

A parcel of ſlender iron wires, carried by the pole of a magnet, as in fig. 29. ſhould avoid each other. If N be the redundant pole, the fluid in each wire will be driven to the remote end, where it muſt repel the ſimilarly ſituated fluid of its neighbour. The ſame external appearance muſt be exhibited by pieces of wire hanging at the deficient pole of the magnet.

The redundant pole of a magnet A (fig. 30.) being held vertically above the centre of two pieces of common iron, moveable round a ſlender pin, renders the middle of each deficient, and their extremities redundant; therefore they ſhould repel each other, and ſpread out. The ſame effect ſhould be produced by the under charged pole of A.

The redundant pole of a magnet A being applied to one branch of the piece of forked iron NCS (fig. 31.), ſhould drive the fluid into its remote parts C, and then the branch NC ſhould be able to induce the magnetic ſtate on a bit of iron D. But if the deficient pole S of another magnet B be applied to the other branch, theſe two actions ſhould counteract each other at C, and the iron ſhould remain indifferent, and fall.—Yet the magnet B alone would equally cauſe C to carry the piece of iron.

It is ſurely unneceſſary to demonſtrate, that the conſequence of this hypotheſis muſt be, that when a magnet puts any piece of iron into the magnetic ſtate, its own magnetiſm is improved. For the induced magnetiſm of the iron is always ſo diſpoſed as to give the fluid in the magnet a greater conſtipation where already condenſed, and to abſtract more fluid from the parts already deficient. If magnetiſm be produced by ſuch a fluid, a magnet muſt always improve by lying any how among pieces of iron.

But the caſe may be very different when magnets are kept in each others neighbourhood. When the overcharged poles of two magnets are placed fronting each other, the redundant fluid in each repels that in the other more than it attracts the remoter redundant iron. The magnets muſt therefore repel each other. Moreover, in rendering them magnetical, the repulſion of redundant fluid, or the attraction of redundant matter of ſome other magnet, had been employed; and when the magnet was removed, ſome of the conſtipated fluid overcame the obſtruction to its uniform diffuſion, and eſcaped into the deficient pole; what remains is withheld by the obſtruction, and the reſtoring forces are juſt in equilibrio with this obſtruction. If we now add to them the repulſion of redundant fluid, directed toward the deficient pole, ſome more of the conſtipated fluid muſt be driven that way, and the magnet muſt be weakened. Nay, it may be deſtroyed, and even reverſed, if one of the magnets be very powerful, and have its own magnetiſm very fixed; that is, if its fluid be very redundant, and meet with very great obſtruction to its motion. Hence it alſo ſhould follow, that the repulſion obſerved between two magnets ſhould be weaker at the ſame diſtance than their attraction, and ſhould follow a different law. For, in the courſe of the experiments, the ſituation of the fluid in the magnets is continually changing, and approaching to a ſtate of uniform diffuſion.

77
Explanation of the directive power, and of polarity.

Let us now examine into the ſenſible effect of this fluid on a magnet which cannot move from its place, but can turn on its centre like a compaſs needle. This ſcarcely requires any diſcuſſion. We ſhould only be repeating, with regard to the redundant fluid and redundant matter, what we formerly ſaid in regard of north pole and ſouth pole; the little magnet muſt arrange itſelf nearly in the tangent of a magnetic curve. But it requires a more minute inveſtigation to determine what the ſenſible phenomenon ſhould be when the fluid of the little magnet is perfectly moveable.

Suppoſe therefore a particle C (fig. 32.) of magnetic fluid, at perfect liberty to move in every direction, and acted on by the redundant and deficient poles of a magnet NAS. The redundant iron in S attracts C in the direction and with the force CF, while the redundant fluid in N repels it in the direction and with the force CD. By their joint action it muſt be urged in the direction and with the force CE, the diagonal of the parallelogram CDEF, which muſt be accurately a tangent to a magnetic curve. If this particle of fluid belong to the piece of iron *n* C *s*, which lies in that very direction, it will unqueſtionably be puſhed towards the extremity *n*. The ſame muſt happen to other particles. Hence it appears that a piece of common iron in this ſituation and poſition muſt become a magnet, and muſt retain this poſition; only the mechanical energy of the lever may change the equilibrium of the magnetic forces a little; becauſe when the piece of iron *n* C *s* has any ſenſible magnitude, the action on its different points will be a little unequal, and may compoſe diagonals which divide a little from the tangent.

Should the iron needle chance not to have the exact poſition, but not deviate very far from it, it is alſo clear that the fluid, not being able to eſcape, will preſs on the ſide toward which it is impelled; and thus will cauſe the needle to turn on its pivot, and finally arrange itſelf in magnetical and mechanical equilibrium, deviating ſo much the leſs from a tangent to a magnetic curve as the piece of iron is ſmaller. Any piece of common iron, held in the neighbourhood of a magnet, will become more overcharged at one end and undercharged at the other, in proportion as the poſition of its length comes nearer to the tangent of a magnetic curve. A ſlender wire held perpendicular to this poſition, that is, perpendicular to the curve, ſhould not acquire any ſenſible magnetiſm, either attractive or directive.

78
Explanation of the curves formed by iron filings.

We ſurely need not now employ many words to ſhew that a parcel of iron filings, ſtrewed round a magnet, ſhould arrange themſelves in the primary magnetic curves, or that when ſtrewed round two magnets they ſhould form the ſecondary or compoſite curves.

79
Explanation of tranſitory and of permanent magnetiſm, and of indifferent and determinate magnetiſm.

Let us now enquire more particularly into the modifications of this accumulation of magnetic fluid which may reſult from the nature of the piece of iron, as it is put into the magnetic ſtate. The propelling force of A acts againſt the mutual repulſion of the particles of fluid in B, and alſo againſt the obſtruction to its motion through the pores of B. The greater this obſtruction, the ſmaller will be the accumulation which ſuffices, in conjunction with the obſtruction and the attraction of the deſerted iron, to balance the propulſive force of the redundant fluid in the overcharged pole of A. This circumſtance therefore muſt limit the accumulation that can be produced in a given time. Therefore the magnetiſm produced on ſoft ſteel or iron ſhould be greater than that produced in hard ſteel at the ſame diſtance. Hence the great advantage of ſoft poles, or of armour, or of capping, to a loadſtone, or to a bundle of hard bars. The beſt form and dimenſions of this armour is certainly determinable by mathematical principles, if we knew the law of magnetical action, and the diſpoſition of the magnetiſm in our loadſtone; but theſe are too imperfectly known in all caſes for us to pretend to give any exact rules. We muſt decide experimentally by making the caps large at firſt, and reducing them till we find the loadſtone carry leſs; then make them a ſmall matter larger. The chief things to be minded are the purity, the uniformity, and the ſoftneſs of the iron, and the cloſeſt poſſible contact.

If the obſtruction reſemble that to motion through a clammy fluid, the final accumulation in hard ſteel may be nearly equal to that in iron, but will require much longer time. Alſo, becauſe ſuch obſtruction to the motion of the fluid will nearly balance the propelling force in parts that are far removed from the magnet, the accumulation will begin thereabouts, while the bar beyond is not yet affected. A redundant pole will be formed in that place. This will operate on what is *immediately* beyond it, driving the fluid farther on, and occaſioning another accumulation at a ſmall diſtance. This may produce a ſimilar effect in a ſtill ſmaller degree farther on. Thus the ſteel bar will have the fluid alternately condenſed and rarefied, and contain alternate north and ſouth poles. This ſtate of diſtribution will not be permanent; fluid will be gradually changing its place; theſe poles will gradually advance along the bar, the remoter poles becoming gradually more diffuſe and faint; and it will not be till after a very long time that a regular magnetiſm with two poles will be produced. To ſtate mathematically the procedure of this mechaniſm would require many pages. Yet it may be done in ſome ſimple caſes, as Newton has ſtated the proceſs of aerial undulation. But we cannot enter upon the taſk in this limited diſſertation. What is ſaid in the Supplementary article Electricity (n° 217, 218.) on the diſtribution of the electric fluid in an imperfect inſulator, will aſſiſt the reader to form a notion of the ſtate of magnetiſm during its induction. That ſuch alternations proceed from ſuch mechaniſm, we have ſufficient proof in the inſtances mentioned in the former part of this article. The wave, or curl, produced on the ſurface of a clammy fluid, is a phenomenon of the ſame kind, and owing to ſimilar cauſes.

When the magnet which has produced all theſe changes is removed, it is evident that a part of this accumulation will be undone again. The repulſion of the condenſed fluid, and the attraction of the deſerted iron, will bring back ſome of the fluid. But it is very evident, that a part of the accumulation will remain, by reaſon of the obſtruction to its motion in returning; and this remainder muſt be ſo much the greater as the obſtruction to the change of ſituation is greater. In ſhort, we cannot doubt but that the magnetiſm which remains will be greater in hard than in ſpring tempered ſteel.

80
Rationale of the proceſs for making magnets.

Thus have we traced the hypotheſis in a great variety of circumſtances and ſituations, and pointed out what ſhould be the external appearance in each. We did not, in each inſtance, mention the perfect coincidence of theſe conſequences with what is really obſerved, but left it to the recollection of the reader. The coincidence is indeed ſo complete, that it ſeems hardly poſſible to refuſe granting that nature operates in this or ſome very ſimilar manner. We get ſome confidence in the conjecture, and may even proceed to explain complicated phenomena by this hypothetical theory. We might proceed to ſhew, that the effects of all the methods practiſed by the artiſts in making artificial magnets are eaſy conſequences of the hypotheſis; but this is hardly neceſſary. We ſhall juſt mention ſome facts in thoſe proceſſes which have puzzled the naturaliſts.

1. A ſtrong magnet is known to communicate the greateſt magnetiſm to a bar of hard ſteel; but Muſchenbroek frequently found, that a weak magnet would communicate more to a ſoft than to a hard bar.

Explanation. When the magnet is ſtrong enough to impregnate both as highly as they are capable of, the hard bar muſt be the ſtrongeſt; but if it can ſaturate neither, the ſpring-tempered bar muſt be left the moſt magnetical.

2. A ſtrong magnet has ſometimes communicated no higher magnetiſm than a weaker one; both have been able to ſaturate the bar.

3. A weak magnet has often impaired a ſtrong one by ſimply paſſing along it two or three times; but a piece of iron always improves a magnet by the ſame treatment.

Explanation. When the north pole of a weak but hard magnet is ſet on the north pole of a ſtrong one, it muſt certainly repel part of the fluid towards the other end, and thus it muſt weaken the magnet. When it is carried forward, it cannot repel this back again, becauſe it is not of itſelf ſuppoſed capable of making the magnet ſo ſtrong. But the end of a piece of iron, always acquiring a magnetiſm oppoſite to that of the part which it touches, muſt increaſe the accumulation of fluid where it is already condenſed, and muſt expel more from thoſe parts which are already deficient.

4. All the parts of the proceſs of the double-touch, as practiſed by Meſſrs Mitchell and Canton, are eaſily explained by this hypotheſis. A particle of fluid p (fig. 33.), ſituated in the middle between the two magnets, is repelled in the direction $p\,e$ by the redundant pole of the magnet AN, whoſe centre of effort is ſuppoſed to

be at C. It is attracted with an equal force in the direction *p d* toward the centre of effort of the deficient pole of AS. By theſe combined actions it is impelled in the direction *p f*. Now it is plain that, although by increaſing the diſtance between N and S, the forces with which theſe poles act on *p* are diminiſhed, yet the compound force *p f* may increaſe by the diminution of the angle *d p e*. If the action is as $\frac{1}{x^2}$, *p f* will be greateſt when $\frac{\text{Coſ.}\ dpf}{dp^2}$ is a maximum, or (nearly) when Sin.^{2} *d p f* × Coſ. *d p f* is a maximum: but this depends on the place of the centre of effort. We can, however, gather from this obſervation, that the nearer we ſuppoſe the centres of effort of the poles N and S to the extremities of the magnets, the nearer muſt they be placed to each other. But we muſt alſo attend to another circumſtance; that by bringing the poles nearer together, although we produce a greater action on the intervening fluid, this action is exerted on a ſmaller quantity of it, and therefore a leſs effect may be produced. This makes a wider poſition preferable; but we have too imperfect a knowledge of the circumſtances to be able to determine this with accuracy. The unfavourable action on the fluid beyond the magnets muſt alſo be conſidered. Yet all this may be aſcertained with preciſion in ſome very ſimple inſtances, and the determination might be of ſervice, if we had not a better method, independent of all hypotheſes or theory; namely, to place the magnets at the diſtance where they are *obſerved* to lift the heavieſt bar of iron; then we are certain that their action is moſt favourable, all circumſtances being combined.

We alſo ſee a ſufficient reaſon for preferring the poſition of the magnets employed by Mr Antheaume (and before him by Mr Servington Savery), in his proceſs for making artificial magnets. The form of the parallelogram *d p e f* is then much more favourable, the diagonal *p f* being much longer.

We alſo ſee, in general, that, by the method of double touch, a much greater accumulation of fluid may be produced than by any other known proceſs.

And, laſtly, ſince no appearances indicate any difference between natural and artificial magnetiſm, this hypotheſis is equally applicable to the explanation of the phenomena of natural magnetiſm; ſuch as the poſition of the horizontal, and of the dipping needle, and the impregnation of natural loadſtones.

Having ſuch a body of evidence for the aptitude of this hypotheſis for the explanation of phenomena, it will ſurely be agreeable to meet with any circumſtances which render the hypotheſis itſelf more probable. Theſe are not wanting; although it muſt be acknowledged that nothing has yet appeared, beſides the phenomena of magnetiſm, to give us any indication of the exiſtence of ſuch a fluid; but there are many particulars in their appearance which greatly reſemble the mechanical properties of a fluid.

81
Probability of the exiſtence of a magnetical fluid.

Heating a rod of iron, and allowing it to cool in a poſition perpendicular to the magnetic direction, deſtroys its magnetiſm. Iron is expanded by heat. If the particles of the magnetic fluid are retained between thoſe of the iron, notwithſtanding the forces which tend to diffuſe them uniformly, they may thus eſcape from between the ferrugineous particles which with-held them. For ſimilar reaſons, magnetiſm ſhould be acquired by heating a bar and letting it cool in the magnetic direction. But, beſides this evident mechanical *opportunity* of motion, the union of fire (or whatever name the neologiſts may chooſe to give to the cauſe of expanſion and of heat) with the particles of iron may totally change the action of thoſe particles on the particles of fluid in immediate contact with them; nay, it may even change the ſenſible law of action between magnet and magnet. Of this no one can doubt who underſtands the application of mathematical ſcience to corpuſcular attraction (See Boscovich, *Suppl.*) A change may be produced in the action between magnets without any remarkable change happening in the actions within the magnet, and it may be juſt the reverſe. The union of fire with the magnetic fluid may increaſe the mutual repulſion of its parts, as it does in all aerial fluids or gaſes. This alone would produce a diſſipation of ſome magnetiſm. It may increaſe the attraction (at inſenſible diſtances) between the fluid and the iron, as it does in numberleſs caſes in chemiſtry.

82
Farther grounds of belief.

It is well known that violently knocking or hammering a magnet weakens its force, and that hammering a piece of iron in the magnetic direction will give it ſome magnetiſm. By this treatment the parts of the iron are put into a tremulous motion, alternately approaching and receding from each other. In the inſtants of their receſs, the pent-up particles of the fluid may make their eſcape. A quantity of ſmall ſhot may be uniformly mixed with a quantity of wheat, and will remain ſo for ever, if nothing diſturb the veſſel; but continue to tap it ſmartly with a ſtick for a long time, and the grains of ſmall ſhot will eſcape from their confinements, and will all go to the bottom. We may conceive the particles of magnetic fluid to be affected in the ſame way. The ſame effect is produced by grinding or filing magnets and loadſtones. The latter are frequently made worthleſs by grinding them into the proper ſhape. This ſhould be avoided as much as poſſible, and it ſhould always be done in moulds made of ſoft iron and very maſſive; but this will not always prevent the diſſipation of *ſtrong* magnetiſm. As a farther reaſon for aſſigning this cauſe for the diſſipation in ſuch caſes, it muſt be obſerved (Muſchenbroek takes notice of it), that a magnet or loadſtone may be ground at its neutral point without much damage. But we had the following moſt diſtinct example of the proceſs. A very fine artificial magnet was ſuſpended by a thread, with its ſouth pole down. A perſon was employed to knock it inceſſantly with a piece of pebble, in ſuch a manner as to make it ring very clearly, being extremely hard and elaſtic. Its magnetiſm was examined from time to time with a very ſmall compaſs needle. In three quarters of an hour, its magnetiſm was not only deſtroyed, but the lower end ſhewed ſigns of a north pole. The ſame magnet was again touched, and made as ſtrong as before, and was then wound about very tight with wetted whipcord, leaving a ſmall part bare in the middle. It was again knocked with the pebble, but could no longer ring. At the end of three quarters of an hour its magnetiſm was ſtill vigorous, and was not near gone after two hours and a quarter. We diſcharged a Leyden jar (coated with gold leaf) in the ſame way. It ſtood on the top of an axis; and while this was turned round, the edge was rubbed with a very dry cork filled with roſin, and faſtened to the end of a glaſs rod. This made the jar ſound like the glaſs of a harmonica. One of them was ſplit in this operation.

A ſmall bar of ſteel was heated red hot and tempered hard between two ſtrong magnets lying in ſhallow boxes filled with water, and was more ſtrongly impregnated in this way than in any other that we could think of for a bar of that ſhape. It has not yet been aſcertained in what temperature it is moſt ſuſceptible of magnetiſm, but it was conſiderably hotter than to be juſt viſible in a dark place. It is no objection to our way of conceiving magnetiſm, that the fluid is immoveable or inactive when the iron is red hot. Either of theſe, or both of them, may reſult from the union with the cauſe of heat. Even a particular degree of expanſion may ſo change the law of action as to make it *immoveable;* or the union with caloric may render it *inactive* at all ſenſible diſtances. We cannot but think, that ſome very inſtructive facts might be obtained by experiments made on iron in the moment of its production, and changes in various chemical proceſſes. All magnetiſm is gone when it is united with ſulphur and arſenic in the greateſt number of ores; and when it is in the ſtate of an ochre, ruſt, æthiops, or ſolution in acids; and when united with aſtringent ſubſtances, ſuch as galls. When, and in what ſtate, does it become magnetic? And whence comes the fluid of Æpinus? It were worth while to try, whether magnets have any influence in the formation or cryſtallization of the martial ſalts; and what will be their effect on iron when precipitated from its ſolutions by another metal, &c. &c.

83
Why magnets have always more than one pole.

There remains one remarkable fact to be taken notice of, which, in one point of view, is a confirmation of the hypotheſis, but in another preſents conſiderable difficulties. It is well known, that no magnet has ever been ſeen which has but one pole; that is, on the hypotheſis of Æpinus, which is wholly redundant, or wholly deficient. If all magnetiſm be either the immediate or the remote effect of the great magnet contained in the earth, and if it be produced by induction, without any communication of ſubſtance, but only by changing the diſpoſition of the fluid already in the iron, we never ſhould ſee a magnet with only one pole. It muſt be owned, that we never can make ſuch a magnet by any of the proceſſes hitherto deſcribed; but the exiſtence of ſuch does not ſeem impoſſible. Suppoſing a magnet, of the moſt regular magnetiſm, having only two poles; and that we cut it through at the neutral point, or that we cut or break off any part of it—the fact is, (for the experiment has been tried ever ſince men began to ſpeculate about magnetiſm), that each part becomes an ordinary magnet, with two poles, one of which is of the ſame kind as before the ſeparation. The queſtion now is, What ſhould happen according to the theory maintained by Æpinus?—*Tentam. Theor. Elect. et Magnetiſmi*, p. 104, &c.

Let NAS (fig. 34.) be a magnet, of which N is the overcharged pole. Let the ordinates of the curve DAE expreſs the difference between the natural denſity of the fluid, in a ſtate of uniform diffuſion, and its denſity as it is really diſpoſed in the magnet. The area *p n* ND will there expreſs the quantity of redundant fluid in the part *n* N, and the area *q* ES *m* expreſſes the fluid wanting in the part S *m*. The interſection A marks that part of the magnet where the fluid is of its natural denſity. Suppoſe the part N*n* to be ſeparated from the reſt, containing the redundant fluid ND*p n*. The tendency of this fluid to eſcape from the iron with which it is connected will be greater (Mr Æpinus thinks) than before; becauſe its tendency to quit the magnet formerly was repreſſed by the attractions of the redundant matter contained in AS. This is certainly true of the extremity N; nay, perhaps of all the old external ſurface. Fluid will therefore eſcape. Suppoſe that ſo much has quitted the iron that the point *n* has the fluid of its natural denſity, as is repreſented in n° 3. there is ſtill a force operating at *n*, tending to eſcape, ariſing from the repulſion of all the redundant fluid *n* DN. If this be ſufficient for overcoming the obſtruction, it will really eſcape, and the iron will be left in the ſtate repreſented by n° 4. with an overcharged part *f* N, and an undercharged part *f n*.

In like manner, the tendency of the magnetic fluid ſurrounding the magnet to enter into its deficient pole, will be greater when it is ſeparated from the other, not being checked by the repulſion of the redundant fluid in that other.

Mr Æpinus relates ſome experiments which he made on this ſubject. The general reſult of them was, that the moment the parts were ſeparated, each had two poles, and that the neutral point of each magnet was much nearer to the place of their former union than to their other ends. In a quarter of an hour afterward, the neutral points had advanced nearer to their middle, and continued to do ſo, by very ſmall ſteps, for ſome hours, and ſometimes days, and finally were ſtationary in their middles.

84
Defects of this reaſoning.

We acknowledge, that this reaſoning does not altogether ſatisfy us, and that the gradual progreſs of the neutral point toward the middle of each piece, although agreeable to what ſhould reſult from an eſcape of fluid, is not a proof of it. We know already, that the induction of magnetiſm is a progreſſive thing; and we ſhould have expected this change of the ſituation of the neutral point, whatever be the nature of magnetiſm. There is ſomething ſimilar to this, and perhaps equally puzzling, in the immediate recovery of magnetiſm which has been weakened by heat; it is partly recovered on cooling.

But our chief difficulty is this: At the point A (fig. 34.) every thing is in equilibrium before the fracture. The particle A is repelled by the redundant fluid in AN, and attracted by the redundant matter in AS; yet it does not move, for the magnetiſm is ſuppoſed to have permanency. Therefore the obſtruction at A cannot be overcome by the united repulſion of AN and attraction of AS. Nor can the obſtruction at N be overcome by the difference of theſe two forces. Now ſuppoſe AS annihilated. The change made on the ſtate of things at A is ſurely greater than that at N, becauſe the force abſtracted is greater, the diſtance being leſs. It does not clearly appear, therefore, that the removal of AS ſhould occaſion an efflux at N. This, however, is not impoſſible; becauſe the fluid may be ſo diſpoſed, by great conſtipation near N, and no great exceſs of denſity near A, that a ſmaller change at N may produce an efflux there. But ſurely the tendency to eſcape at A muſt now be diminiſhed, inſtead of being greater after the fracture. And if any eſcape from N, this will ſtill more diminiſh that tendency to eſcape from A. It does not therefore appear a clear conſequence of the general theory, that the conſtipated fluid ſhould eſcape; and more particularly, that A ſhould become deficient. And with reſpect to the entry of fluid into the other fragment, and its becoming overcharged at *m*, the reaſoning ſeems ſtill leſs convincing. The ſteps of the phyſical proceſs in the two parts of the original magnet are by no means convertible or counterparts of each other. There is nothing in the part AS to reſemble the force of repulſion really exerting itſelf in the correſponding point of AN. There would be, if there were a particle of fluid in that place; but there is not. The tendency therefore of external fluid to enter there, does not reſemble the tendency of the internal fluid to expand and diſſipate. It is true, indeed, the diſcourſe ſhould be confined to points of the ſurface. But the internal motion muſt alſo be conſidered; and the great objection always remains, namely, that the obſtruction at A (n° 1.) or at *n* (n° 3.) is ſufficient to prevent the paſſage of a particle of fluid from the pole AN into the pole AS, when urged by the repulſion of the fluid in the one and the attraction of the iron in the other; and yet will not prevent the eſcape of a particle when one of thoſe cauſes of motion is removed. Add to this, that the whole hypotheſis aſſumes as a principle, that the reſiſtance to eſcape from any point is greater than the obſtruction to motion through the pores. This is readily granted; for however great we ſuppoſe the attraction, in the limits of phyſical contact, it will be no obſtruction to motion through the pores, becauſe the particle is equally affected by the oppoſite ſides of the pores; whereas, in quitting the body altogether, there is nothing beyond the body to counteract the attraction by which it is retained.

There ſeems ſomething wanting to accommodate this beautiful hypotheſis of Mr Æpinus to this remarkable phenomenon; and the coincidence is otherwiſe ſo complete, that we are almoſt obliged to conclude that it is merely a deficiency, ariſing from our not having a ſufficient knowledge of the law of magnetic action. This is quite ſufficient: For it may be ſtrictly demonſtrated, that if the magnetic action decreaſes in higher ratio than that of the ſquares of the diſtances, the permanency of the fluid in any particular diſpoſition has ſcarcely any dependence on the particles at any ſenſible diſtance, and is affected only by the *variations* of its denſity (See Electricity, *Suppl.* n° 217. for a caſe ſomewhat ſimilar). Therefore, if the fluid be ſo diſpoſed, that its denſity may be repreſented by the ordinates of ſuch a curve as is drawn in fig. 34. having its two extremities concave toward the axis, and a point of contrary flexure at A, the tendency to eſcape at A will be the greateſt poſſible; and when the magnet is broken at A (n° 1.), or when the fluid has taken the arrangement repreſented by n° 3. it *cannot* ſtop there, and *muſt* become deficient in that part. Now, it muſt be acknowledged, that we are not abſolutely certain that the magnetic action is in the preciſe inverſe duplicate ratio of the diſtance. All that we are certain of is, that it is much nearer to it than to either the inverſe ſimple or inverſe triplicate ratio. We own ourſelves rather diſpoſed to aſcribe the preſent difficulty to our ignorance of ſome circumſtance, purely mathematical, overlooked, or miſtaken, than to think a conjecture unfounded, which tallies ſo accurately with ſuch a variety of phenomena.

We may here obſerve, that we are not altogether ſatisfied with Æpinus's form of the experiment. He did not break a magnet; he ſet two ſteel bars end to end, and touched them as one bar, making the magnetiſm perfectly regular; he then ſeparated them, and found that each had two poles. But was he certain that, when joined, they made but one magnet? We have ſometimes ſucceeded in doing this, as we thought, by the curves of iron filings; but on putting the needle with which we were examining their polarity into proper ſituations, we ſometimes found it in the ſecond interſection of the ſecondary curves, ſhewing that the bars were really two magnets, and not one.

On the other hand, when a piece is broken off from a magnet, the ſuccuſſion and elaſtic tremor into which the parts are thrown, and even the bending previous to the fracture, may give opportunity to a diſſipation, which could not otherwiſe happen. The parts ſhould be ſeparated by corroſion in an acid, and the gradual change of magnetiſm ſhould be carefully noted. The writer of this article has made ſome experiments of this nature, the reſults of which preſent ſome curious obſervations: but they are not yet brought to a concluſion that is fit to be laid before the public.

85 Hypotheſis of Prevôt.

Mr Prevôt of Geneva, in a diſſertation on the origin of magnetic forces, endeavours to give a theory which obviates the only difficulty in that of Æpinus; but it is incomparably more complex, employing two fluids, which by their union compoſe a third, which he calls combined fluid. There is much ingenuity, and even mathematical addreſs, in adjuſting the relative properties of thoſe fluids. But ſome of them are palpably incompatible; *ex. gr.* the particles of each attract each other, but thoſe of the other kind moſt ſtrongly; yet they are both elaſtic like air. This is ſurely inconceivable.—Granting this, however, he ſuits his different attractions, ſo that a ſtrong elective attraction of the combined fluid for iron decompoſes part of the fluid in the iron, and each of its ingredients occupies oppoſite ends of the bar: then will the bars approach or recede, according as the near ends contain a different or the ſame ingredient. All this is operated without repulſion.

But the whole of this is mere accommodation, like Æpinus's, but ſo much more complex, that it requires very intenſe contemplation to follow the author through the conſequences. Add to this, that his attractions are operated by another fluid, infinitely more ſubtle than either of thoſe already mentioned, every particle of theſe being, as it were, a world in compariſon of thoſe of the other. In ſhort, he adopts all the extravagant ſuppoſitions of Le Sage of Geneva, and every thing is ultimately impulſion. Nor is the contrivance for obviating the difficulty (ſo often mentioned) at all clear and convincing; and it is equally gratuitous with the reſt. We cannot think this hypotheſis at all intitled to the name of *explanation*.

86 Remarks on hypotheſes.

This muſt ſerve for an account of the hypotheſis of Æpinus. The philoſophical reader will ſee, that however exactly it may tally with every phenomenon, it cannot be called an explanation of the phenomena; becauſe it is the phenomena which explain the hypotheſis, or give us the characters of the magnetic fluid, if ſuch fluid exiſts. But we are not obliged to admit this exiſtence, as we admit that to be the true decyphering of a letter which makes ſenſe of it. In that caſe we know both parts of the ſubject—the characters and the ſounds; but are ignorant which correſponds to which. Did we ſee a fluid abſtracted from one part of a bar and conſtipated in another, and perceive the abſtraction and conſtipation always accompanied by the obſerved attractions and repulſions, the rules of philoſophical diſcuſſion, nay, the conſtitution of our own mind, would oblige us to aſſign the one as the cauſe or occaſion of the other. But this important circumſtance is wanting in the preſent caſe. We think, however, that it merits a cloſe attention; and we entertain great hopes of its being one day completed, by including this ſingle exception.

At the ſame time, it muſt be owned, that it gives no extenſion of knowledge; for it can have no greater extenſion than the phenomena on which it is founded, and cannot, without riſk of error, be applied to an untried caſe, of a kind diſſimilar in its nature to the phenomena on which it is founded. We doubt not but that its ingenious author would have ſaid, that a bit broken off from the north pole of a magnet would be wholly a north pole, if he had not known that the fact was otherwiſe.

But this hypotheſis greatly aids the imagination in conceiving the proceſs of the magnetical phenomena. The more we ſtudy them, the more do they appear to reſemble the protruſion of a fluid through the parts of an obſtructing body. It proceeds gradually. It may be, as it were, overdone, and regorges when the propelling cauſe is removed. The motion is aided by what we know to aid other obſtructed motions. As a fluid would be conſtipated in all protuberances, ſo the faculty of producing the phenomena is greater in all ſuch ſituations, &c. &c. This, joined to the impoſſibility of ſpeaking, with clearneſs of conception, of the propagation of powers without the protruſion of ſomething in which they inhere, gives it a hold of the imagination which is not eaſily ſhaken off.

To ſay that nothing is explained when the attraction of the fluid is not explained, and that this is the main queſtion, gives us little concern. We offer no explanation of this attraction, more than of the attraction of gravity. There is nothing contrary to the laws of human intellect, nothing inconſiſtent with the rules of reaſoning, in ſaying, that things are ſo conſtituted, that when two particles are together, they ſeparate, although we are ignorant of the immediate cauſe of their ſeparation. Thoſe who think that all motion is performed by impulſion, and who explain magnetiſm by a ſtream of fluid circulating round the magnet, muſt have another fluid to impel this fluid into its curvilineal path; for they inſiſt, that the planets are ſo impelled. Then they muſt have a third fluid to deflect the vertical motions of the ſecond, and ſo on without end. This is evident, and it is abſurd. But we have ſaid enough in the article IMPULSION, *Suppl.* to ſhew that all *hypotheſes* framed on purpoſe to explain action *e diſtanti* by impulſion are illogical; becauſe impulſion requires explanation as much as the other, and neither the one nor the other will ever be reſolved into any thing but the FIAT of the Allwiſe Author of the univerſe.

87 The preceding theory is not a hypotheſis.

We conclude with deſiring the reader to remark, that the explanation which we have given of the magnetical phenomena is independent of the hypotheſis of Æpinus, or any hypotheſis whatever. We have narrated a variety of very diſtinguiſhable facts, and have marked their diſtinctions. We have been able to reduce them to general claſſes; and even to groupe thoſe claſſes into others ſtill more general; and at laſt, to point out one which is diſcoverable in them all. This is giving a philoſophical theory, in the ſtricteſt ſenſe of the word; becauſe we ſhew, in every caſe, the modification of the general fact which allots it this or that particular place in the claſſification. Thus we have ſhewn that the polarity or directive power of magnets is only a modification of the general fact of attraction and repulſion. Dr Gilbert's theory of *terreſtrial* magnetiſm is indeed a hypotheſis, and we enounced it as ſuch. It only claims probability, and we apprehend that a very high degree of credit will be given to it.

We hope that many of our readers will have their curioſity excited by the account we have given of Æpinus's theory. To ſuch we earneſtly recommend the ſerious peruſal of his book *Tentamen Theoriæ Electricitatis et Magnetiſmi, Auct. F. Æpino, Petropoli,* 1759. Van Swinden has included a very good abſtract of it in his 2d volume *Sur l'Electricité*, written by Profeſſor Steiglehner of Ratiſbon or Ingolſtadt. The mathematical part is greatly ſimplified, and the whole is preſented in a very clear and accurate manner. Mr Van Swinden is a profeſſed foe to all hypotheſes; but he is not moderate, and we wiſh that we could ſay that he is candid. He attacks every thing; and takes the opportunity of every analogy pointed out by Æpinus between magnetiſm and electricity to repeat the firſt ſentence of his diſſertation, namely, that magnetiſm and electricity are not the ſame; a thing that Æpinus alſo maintains. But he even charges Æpinus with a miſtake in his fundamental equations, which invalidates his whole theory. He ſays that Æpinus has omitted one of the acting forces aſſumed in his hypotheſis. This is a moſt groundleſs charge; and we own that we cannot conceive how Van Swinden could fall into ſuch a miſtake. We are unwilling to call it intentional, for the mere purpoſe of raiſing a man of ſtraw to knock him down again. Abbé Haüy of the French Academy has alſo publiſhed an abridgment of Æpinus's theory, with many excellent remarks, tending to clear the theory of the only defect that has been found in it. This work was much approved of, and recommended by the Academy. We have not had the good fortune to ſee a copy of it.

88 Analogy of magnetiſm and electricity.

The reader cannot but have remarked the cloſe analogy between the magnetical phenomena and thoſe of induced electricity; indeed, all the phenomena of attraction and repulſion are the ſame in both. The mechanical compoſition of thoſe actions produces a directive power and a polarity, in electrical as well as in magnetical bodies. We can make an electrical needle which will arrange itſelf, with reſpect to the overcharged and undercharged ends of a body electrified by mere poſition, juſt as a compaſs needle is arranged by a magnet. We can touch a ſtick of ſealing wax in the manner of the double touch, ſo as to give it poles of conſiderable force and durability. As a red hot ſteel bar acquires permanent poles by quenching it near a magnet, ſo melted wax acquires them by freezing in the neighbourhood of a poſitive and negative electric. Some have inferred a ſameneſs of origin of theſe two ſpecies of powers from thoſe various circumſtances of reſemblance; but the original cauſes ſeem to be diſtinct on many accounts. Electricity is common to all bodies. The cauſe of magnetiſm can operate only on iron. Although lightning or an electrical ſhock gives polarity to a needle, we need not infer the identity of the cauſe, becauſe the polarity which it gives is always the ſame with that given by great heat; and there is always intenſe heat in this operation. The phenomenon which looks the moſt like an indication of identity of the origin of electricity and magnetiſm is the direction of the rays of the aurora borealis—they converge to the ſame point of the heavens to which the elevated pole of the dipping needle directs itſelf. But this is by no means a ſufficient foundation for eſtabliſhing a ſameneſs. Electricity and magnetiſm may, however, be related by means of ſome powers hitherto unknown. But we are decidedly of opinion, that the electric and magnetic fluid are totally different, although their mechanical actions are ſo like that there is hardly a phenomenon in the one which has not an exact counterpart in the other. But we ſee them both operating, with all their marks of diſtinction, in the ſame body; for iron and loadſtones may be electrified, like any other body, and their magnetiſm ſuffers no change or modification. We can ſet theſe two forces in oppoſition or compoſition, juſt as we can oppoſe or compound gravity with either. While the iron filings are arranging themſelves round a magnet, the mechanical action of electricity may be employed either to promote or hinder the arrangement. They are therefore diſtinct powers, inherent in different ſubjects.

89 They are not, however, effects of the ſame cauſe.

But there are abundance of other phenomena which ſhew this diverſity. There is nothing in magnetiſm like a body overcharged or undercharged *in toto*. There is nothing which indicates the preſence of the fluid to the other ſenſes—nothing like the ſpark, the ſnap, the viſible diſſipation; becauſe the magnetic fluid enters into no union with air, or any thing but iron. There is nothing reſembling that inconceivably rapid motion which we ſee in electricity; the quickeſt motion of magnetiſm ſeems inferior (even beyond compariſon) with the ſloweſt motion along any electric conductor. Therefore there is no poſſibility of diſcharging a magnet as we diſcharge a coated plate. Indeed, the reſemblance between a magnet and a coated plate of glaſs is exceedingly ſlight. The only reſemblance is between the magnet and an inconceivably thin ſtratum of the glaſs, which ſtratum is poſitive in one ſide and negative in the other. The only perfect reſemblance is between the induced magnetiſm of common iron, and the induced electricity of a conductor.

The following ſeem the moſt inſtructive diſſertations on magnetiſm, either as valuable collections of obſervations, or as judicious reaſonings from them, or as the ſpeculations of eminent or ingenious men concerning the nature of magnetiſm.

Gilbertus de Magnete, Lond. 1600, fol.

Æpini Tentamen Theoriæ Magn. et Electr.

Eberhard's Tentam. Theor. Magnetiſmi, 1720.

Diſſertations ſur l'aimant, par du Fay, 1728.

Muſchenbroek Diſſert. Phyſico Experimentalis de Magnete.

Pieces qui ont emporté le prix de l'Acad. des Sciences à Paris ſur la meilleure conſtruction des Bouſſoles de declination. Recueil des pieces courounées, tom. v.

Euleri opuſcula, tom. iii. continens Theoriam Magnetis, Berlin, 1751.

Æpini Oratio Academica, 1758.

Æpini item Comment. Petrop. nov tom. x.

Anton. Brugmanni tentam. Phil. de materia Magnetica, Francqueræ, 1765.

There is a German tranſlation of this work by Eiſenbach, with many very valuable additions.

Scarella de Magnete, 2 tom fol.

Van Swinden Tentamina Magnetica, 4to.

Van Swinden ſur l'Analogie entre les phenomenes Electriques et Magnetiques, 3 tom. 8vo.

Diſſertation ſur les Aimans artificielles par Antheaume.

Experiences ſur les Aimans artificielles par Nicholas, Fuſs, 1782.

Eſſai ſur l'Origine des Forces Magnetiques par Mr Prevoſt.

Sur les Aimans artificielles par Rivoir, Paris 1752.

Diſſertatio de Magnetiſmo par Sam. Klingenſtier et Jo. Brander, Holm. 1752.

Deſcription des Courants Magnetiques, Straſbourg, 1753.

Traité de l'Aiman par Dalancé, Amſt. 1687.

Beſides theſe original works, we have ſeveral diſſertations on magnetical vortices by Des Cartes, Bernoulli, Euler, Du Tour, &c. publiſhed in the collections of the works of thoſe authors, and many diſſertations in the memoirs of different academies; and there are many popular treatiſes by the traders in experimental philoſophy in London and Paris. Dr Gown Knight, the perſon in Europe who was moſt eminently ſkilled in the knowledge of the phenomena, alſo publiſhed a diſſertation intitled, *An attempt to explain the Phenomena of Nature by two principles, Attraction and Repulſion*, Lond. 1748, 4to, in which he has included a theory of magnetiſm. It is a very curious work, and ſhould be ſtudied by all thoſe who have recourſe without ſcruple to the agency of inviſible fluids, when they are tired of patient thinking. They would there ſee what thought and combination are neceſſary before an inviſible fluid can be really fitted for performing any office we chooſe to aſſign it. And they will get real inſtruction as to what ſervices we may expect of ſuch agents, and from what taſks they muſt be excluded. The Doctor's theory of magnetiſm is very unlike the reſt of the performance; for he does not avail himſelf of the vaſt apparatus of propoſitions which he had eſtabliſhed, and adopts without any nice adjuſtment the moſt common notions of an impulſive vortex. Both the production and maintenance of this vortex, and its mode of operation, are irreconcileable with the acknowledged laws of impulſion.

Si quid noviſti rectius iſtis, candidus imperti—ſi non—his utere mecum.

APPENDIX.

Inveſtigation of the magnetic curve.

We have been favoured with the following inveſtigation of the curves, to which a needle of indefinite minuteneſs will be a tangent, by Mr Playfair, Profeſſor of Mathematics in the Univerſity of Edinburgh.

Two magnetical poles being given in poſition, the force of each of which is ſuppoſed to be as the mth power of the diſtance from it reciprocally, it is required to find a curve, in any point of which a needle (indefinitely ſhort) being placed, its direction, when at reſt, may be a tangent to the curve?

1. Let A and B (fig. 35.) be the poles of a magnet, C any point in the curve required; then we may ſuppoſe the one of theſe poles to act on the needle only by repulſion, and the other only by attraction, and the direction of the needle, when at reſt, will be the diagonal of a parallelogram, the ſides of which repreſent theſe forces. Therefore, having joined AC and BC, let AD be drawn parallel to BC, and make $\frac{1}{AC^m} : \frac{1}{BC^m} :: AC : AD$; join CD, then CDF will touch the curve in C.

2. Hence an expreſſion for AF may be obtained. For, by the conſtruction, $AD = \frac{AC^{m+1}}{BC^m}$, and ſince $BC : AD :: BF : FA$, and $BC - AD : AD :: AB : AF$, we have $AF = \frac{AB \times AC^{m+1}}{BC^{m+1} - AC^{m+1}}$.

3. A fluxionary expreſſion for AF may alſo be found in terms of the angles CAB, ABC. In CF take the indefinitely ſmall part CH, draw AH, BH, and from C draw CL perpendicular to AH and CK to BH. Draw alſo BC and AM at right angles to FH. Let the angles $CAB = \varphi$, and $CBA = \psi$; then $CAH = \dot{\varphi}$, and $CBH = -\dot{\psi}$; alſo $CL = AC \times \dot{\varphi}$, and $CK = -BC \times \dot{\psi}$. Now $HC : CL :: AC : AM = \frac{AC^2 \times \dot{\varphi}}{HC}$; and for the ſame reaſon $BC = -\frac{BC^2 \times \dot{\psi}}{HC}$. Therefore ſince $AF : FB :: AM : BC$, $AF : FB :: \frac{AC^2 \times \dot{\varphi}}{HC} : -\frac{BC^2 \times \dot{\psi}}{HC}$, and $AF : AB :: \text{ſin.}\,\psi^2\,\dot{\varphi} : -\text{ſin.}\,\psi^2\,\dot{\varphi} - \text{ſin.}\,\varphi^2\,\dot{\psi}$; wherefore if $AB = a$, $AF = \frac{-a\,\dot{\varphi}\,\text{ſin.}\,\psi^2}{\dot{\psi}\,\text{ſin.}\,\varphi^2 + \dot{\varphi}\,\text{ſin.}\,\psi^2}$.

4. If this value of AF be put equal to that already found, a fluxionary equation will be obtained, by the integration of which the curve may be constructed. Becauſe $AF = \frac{AB \times AC^{m+1}}{BC^{m+1} - AC^{m+1}}$; and ſince $AC = \frac{a\,\text{ſin.}\,\psi}{\text{ſin.}\,(\varphi + \psi)}$, and $BC = \frac{a\,\text{ſin.}\,\varphi}{\text{ſin.}\,(\varphi + \psi)}$, we have by ſubſtitution $AF = \frac{a\,\text{ſin.}\,\psi^{m+1}}{\text{ſin.}\,\varphi^{m+1} - \text{ſin.}\,\psi^{m+1}} = -\frac{a\,\dot{\varphi}\,\text{ſin.}\,\psi^2}{\dot{\psi}\,\text{ſin.}\,\varphi^2 + \dot{\varphi}\,\text{ſin.}\,\psi^2}$. Hence, $\text{ſin.}\,\varphi^2 \times \dot{\psi}\,\text{ſin.}\,\psi^{m+1} + \dot{\varphi}\,\text{ſin}\,\psi^{m+3} = -\text{ſin.}\,\psi^2 \times \dot{\varphi}\,\text{ſin.}\,\varphi^{m+1} + \dot{\varphi}\,\text{ſin.}\,\psi^{m+3}$, and therefore $\dot{\psi}\,\text{ſin.}\,\psi^{m-1} = -\dot{\varphi}\,\text{ſin.}\,\varphi^{m-1}$; and alſo, $\int \dot{\psi}\,\text{ſin.}\,\psi^{m-1} + \int \dot{\varphi}\,\text{ſin.}\,\varphi^{m-1} = C$.

5. Theſe fluents are eaſily found when m is any whole poſitive number.

If $m = 1$, we have $\dot{\psi} + \dot{\varphi} = 0$.
$m = 2$, $\dot{\psi}\,\text{ſin.}\,\psi + \dot{\varphi}\,\text{ſin.}\,\varphi = 0$.
$m = 3$, $\dot{\psi}\,\text{ſin.}\,\psi^2 + \dot{\varphi}\,\text{ſin.}\,\varphi^2 = 0$.
$m = 4$, $\dot{\psi}\,\text{ſin.}\,\psi^3 + \dot{\varphi}\,\text{ſin.}\,\varphi^3 = 0$, &c.
Therefore, &c.

Alſo if $m = 1$, $\varphi + \psi = C$.
$m = 2$, $\text{coſ.}\,\varphi + \text{coſ.}\,\psi = C$.
$m = 3$, $-\text{ſin.}\,2\varphi + 2\varphi - \text{ſin.}\,2\psi + 2\psi = C$.
$m = 4$, $\text{coſ.}\,3\varphi - 9\,\text{coſ.}\,\varphi + \text{coſ.}\,3\psi - 9\,\text{coſ.}\,\psi = C$, &c. &c.

The firſt of the above equations belongs to a ſegment of a circle deſcribed upon AB, which therefore would be the curve required if the magnetical force were inverſely as the diſtances.

If the magnetical force be inverſely as the ſquare of the diſtance, that is, if $m = 2$, $\text{coſ.}\,\varphi + \text{coſ.}\,\psi$ is equal to a conſtant quantity. Hence if, beſide the points A and B, any other point be given in the curve, the whole may be deſcribed. For inſtance, let the point E (fig. 36.) be given in the curve, and in the line DE which biſects AB at right angles. Deſcribe from the centre A a circle through E, viz. QER; then AD being the coſine of DAE to the radius AE, the ſum of the coſines of $\varphi \times \psi$ will be everywhere (to the ſame radius) = 2 AD = AB. Therefore to find E′, the point in which any other line AN, making a given angle with AB, meets the curve, draw from N, the point in which it meets the circumference of the circle QER, NO, perpendicular to AB, ſo that AO may be the coſine of NAO, and from O toward A take OP = AB, then AP will be the coſine of the angle ABE′; ſo to find BE′, draw PQ perpendicular to AP, meeting the circle in Q; join AQ, and draw BE′ parallel to AQ, meeting AE′ in E′, the point E′ is in the curve. In this way the other points of the curve may be found.

The curve will paſs through B, and will cut AB at an angle of which the coſine = RB. If then E be ſuch, that AE = AB, the curve will cut AB at right angles. If E″ be more remote from A, the curve will make with AB an obtuſe angle toward D; in other caſes it will make with it an acute angle.

A conſtruction ſomewhat more expeditious may be had by deſcribing the ſemicircle AFB, cutting AE in F, and AE′ in N, and deſcribing a circle round A, with the diſtance AL = 2AF, cutting AE′ in b. If AG be applied in the ſemicircle AFB = Nb, AG muſt cut AN in a point E′ of the curve, becauſe AN + BG = 2 AF, and AN and GB are coſines of the angles at A and B.

As the lines AN and BG may be applied either above or below AB, there is another ſituation of their interſection E′. Thus An being applied above, and Bg below, the interſection is in e′. The curve has a branch extending below A; and if De be made = DE, and Be be drawn, it will be an aſſymptote to this branch. There is a ſimilar branch below B. But theſe portions of the curve evidently ſuppoſe an oppoſite direction of one of the two magnetic forces, and therefore have no connection with the poſition of the needle.

Addition to n° 65.

We omitted the inſerting in its proper place, n° 65. a hypotheſis of the celebrated aſtronomer Tobias Mayer of Gottingen, by which the direction of the mariner's needle in all parts of the earth may be determined. He ſuppoſes that the earth contains a very powerful magnet of inconſiderable dimenſions, which arranges the needle according to the known laws of magnetiſm. The centre of this magnet was diſtant from the centre of the earth about 480 Engliſh miles in 1756, and a line joining theſe centres interſected the earth's ſurface in a point ſituated in 17° N. Lat. and 183° E. Long. from London. The axis of the magnet is perpendicular to this line, and the plane in which it lies is inclined about 11° to the plane of the meridian, the north end of the axis lying on the eaſt ſide of that meridian.

From theſe data, it will be found that the axis of this magnet cuts the ſurface of the earth about the middle of the eaſtern ſhore of Baffin's Bay, and in another point about 800 miles S.S.W. of the ſouthern point of New Zealand. Profeſſor Lichtenberg of Gottingen, who gives this extract from the manuſcript, ſays, that the hypotheſis is accompanied by a conſiderable liſt of variations and dips calculated by it, and compared with obſervations, and that the agreement is very remarkable. He gives indeed a dozen inſtances in very different regions of the earth. But we ſuſpect that there is ſome error or defect in the data given by him, becauſe the annual changes, which he alſo gives, are ſuch as are inconſiſtent with the data, and even with each other. He ſays, that the diſtance from the centre increaſes about four miles annually, and that *thence* ariſes an annual diminution of 8 minutes in the latitude and 14 in the longitude of that point where the ſtraight line joining the centres meets the ſurface. It can have no ſuch conſequence. He ſays alſo, that the above mentioned inclination of the planes increaſes 8 minutes annually. The compound force of the magnet is ſaid to be as the ſquare root of the diſtance inverſely. We are at a loſs to underſtand the meaning of this circumſtance; becauſe Mayer's hypotheſis concerning the law of magnetic action is exceedingly different, as related by Mr Lichtenberg from the ſame manuſcript. But it was our duty to communicate this notice, though imperfect, of the ſpeculations of this celebrated mathematician. See *Exliben's Elem. of Nat. Phil.* publiſhed by Lichtenberg 1784, p. 645.

Addition to n° 64.

Addition to n° 64.

Let HZOF (fig. 37.) be the plane of a magnetic meridian, H n' O the plane of the horizon, and NS the poſition of the magnetic needle in any place, when it is at liberty to ſettle in the true magnetic direction. The angle HON is the inclination or dip of the needle. Let Z n F be a vertical circle, in which a well conſtructed dipping needle can freely play up and down. This needle cannot place itſelf in the magnetic direction, becauſe it can only move in a vertical plane. Its north point is impelled in the direction $n\,o$, and its ſouth point in the direction $s\,p$, both of which are parallel to NS. By the laws of mechanical equilibrium, it cannot reſt, except in ſuch a poſition that the forces $n\,o$ and $s\,p$ are in a plane perpendicular to the plane Z n F. In any other poſition, there would be a force impelling the needle toward that ſide on which $n\,o$ makes an acute angle with the tangent $r\,n\,t$ of the vertical circle. Therefore the ſpherical triangle N n F is right angled in n, and Coſ. NFn : R = Tan. nF : Tan. NF, = Tan. HN : Tan. $n'\,n$. Therefore

$$\text{Tan. } n'n = \frac{\text{Tan. HN}}{\text{Coſ. H}n'}, = \text{Tan. HN} \times \text{Sec. H}n'.$$

Therefore, in any place, the real inclination of the magnetical direction to the horizon is different from what is pointed out by a dipping needle when it is in a plane which declines from the magnetic meridian; and the tangent of the obſerved dip of the needle exceeds that of the inclination of the magnetic direction in the proportion of radius to the coſine of the deviation HC n', or the proportion of the ſecant of this angle to the radius. If therefore the dipping needle play in a magnetic eaſt and weſt circle, it will ſtand perpendicular to the horizon.

Maleſherbes.

MALESHERBES (Chriſtian William de Lamoignon) was born December the 6th 1721. At the age of 24 he became a counſellor of Parliament, and ſix years afterwards chief preſident of the *cour des aides*. He remained in that important ſituation during a period of 25 years, and diſplayed on many occaſions proofs of firmneſs, eloquence, and wiſdom.

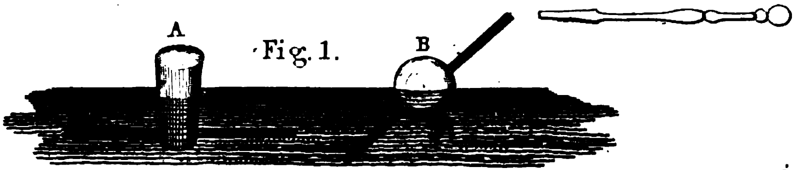
When the prince of Condé was ſent by the king in 1768 to ſilence the magiſtrates who oppoſed the taxes, Maleſherbes replied to him, "Truth, Sir, muſt indeed be formidable, ſince ſo many efforts are made to prevent its approach to the throne." About the ſame time that he became preſident of the *cour des aides*, he was appointed by his father, then chancellor of France, ſuperintendant of the preſs; an office of the greateſt importance, of which the principles which Maleſherbes had imbibed from D'Alembert rendered him very ill qualified to diſcharge the duties. He was what the French called a *philoſopher*; a term with them of the ſame import with a naturaliſt, who openly denies revealed religion, and has no adequate notions of the moral attributes of God. The conſequence was, that when the authors of impious and immoral books were brought before him in his official capacity to undergo examination, he appeared to them as adviſing, aſſiſting, and protecting them, againſt that very power which was veſted in himſelf; and they were commonly diſmiſſed with this ſenſeleſs obſervation, that all books of whatever tendency ſhould be conſidered merely as *objects of commerce*. Had it not been for the protecting influence of Maleſherbes, the *Encyclopedie*, of which the publication was frequently ſuſpended (ſee DIDEROT in this *Supplement*), would probably have been altogether ſuppreſſed; and the works of Rouſſeau and Raynal, which ſo powerfully contributed to that revolution in which he was overwhelmed, would certainly not have ſpread ſo rapidly over the kingdom of France. It was he, ſaid D'Alembert, who *broke the ſhackles of literature*.

Maleſherbes.

In vain will it be replied, that he left the ſame liberty to the religious as to the impious writers; for that was not always ſtrictly true. The Abbé Barruel has brought the teſtimony of D'Alembert himſelf to prove, that it was much againſt his will that Maleſherbes ſuffered works refuting the ſophiſters to appear; and, as he very properly obſerves, what a miniſter allows with reluctance, he finds abundant means of preventing.

In 1775 he reſigned the office of chief preſident of the *cour des aides*, and was appointed miniſter and ſecretary of ſtate in the place of La Vrillière. Thus placed in the centre of a frivolous yet brilliant court, Maleſherbes did not in the leaſt deviate from his former ſimplicity of life and manners; but, in lieu of complying with the eſtabliſhed etiquette which required magiſtrates, when they became miniſters of ſtate, to exchange their ſable habit and head dreſs for a coloured ſuit, bag-wig, and ſword, he retained his black coat and magiſterial *peruke!* This is recorded by a panegyriſt to his honour; but we perceive not the honour which

MAGNETISM. PLATE XXXIV.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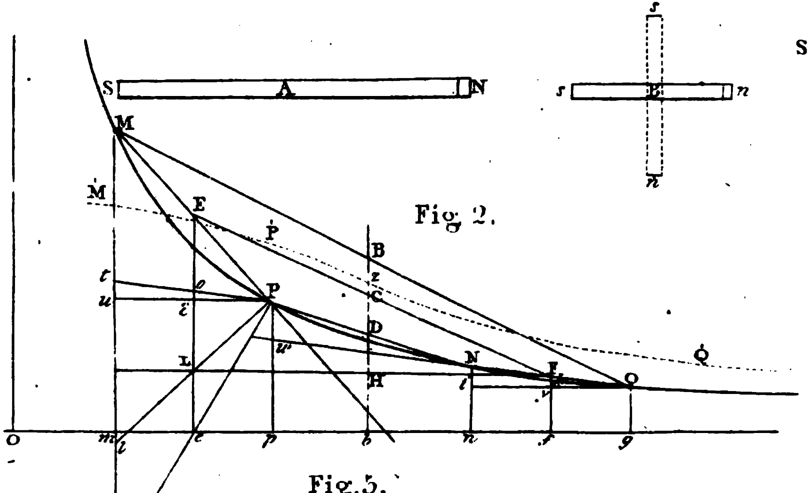
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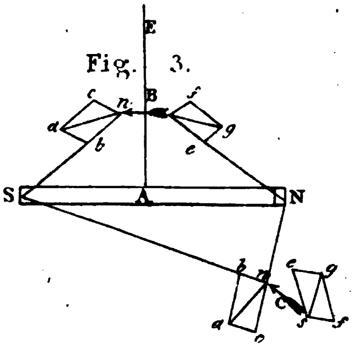
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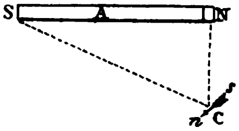
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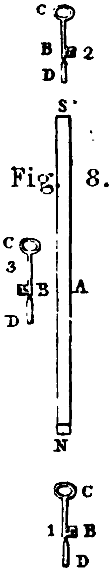
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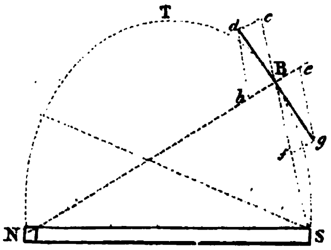
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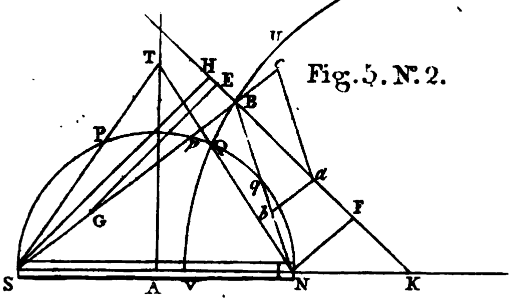
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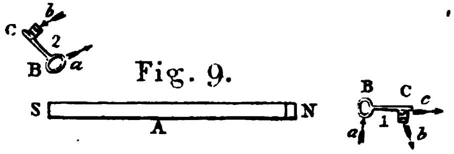
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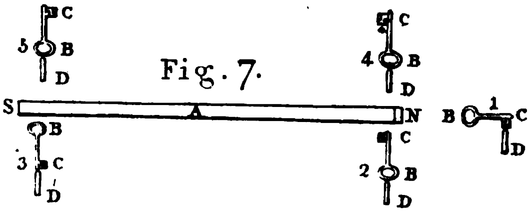
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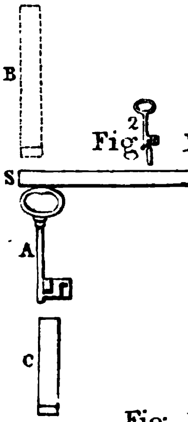
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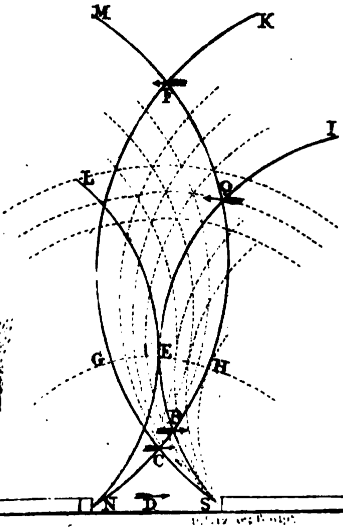
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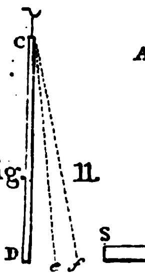
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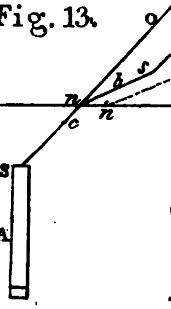
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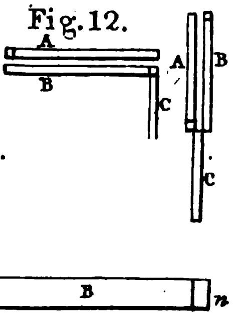
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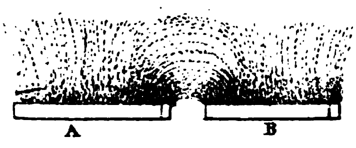
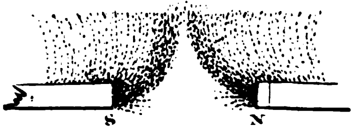


Fig. 14.

Fig. 15.



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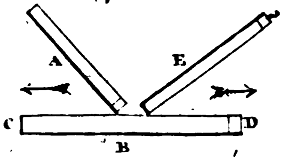

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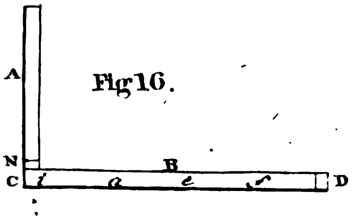

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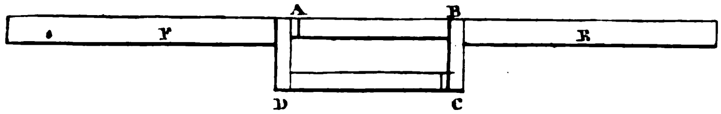
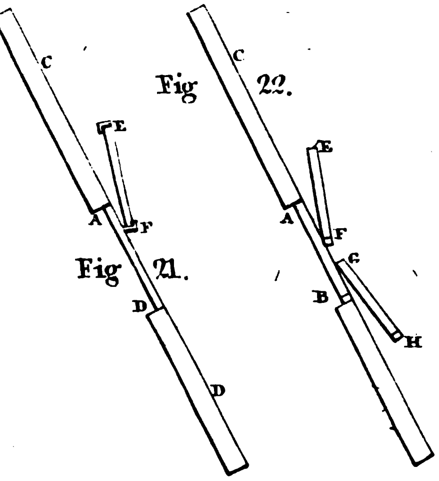


Fig 22.

Fig 21.



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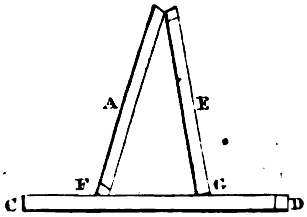

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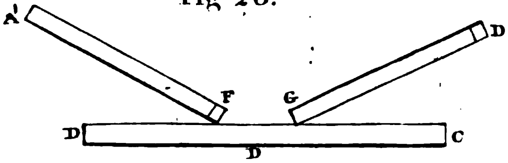

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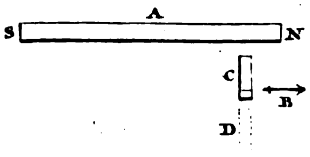

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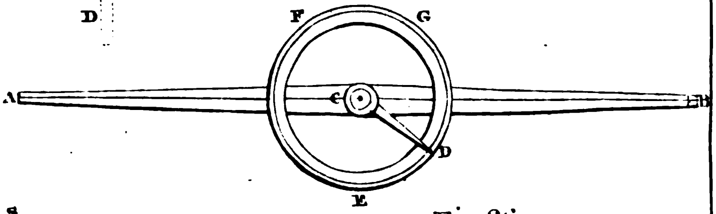

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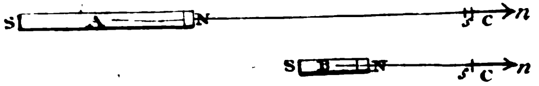

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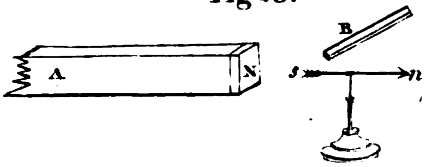

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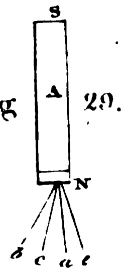

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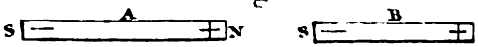

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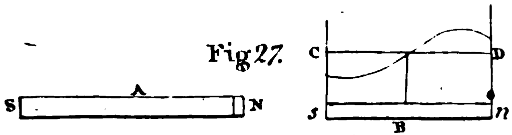

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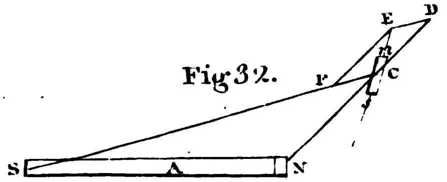

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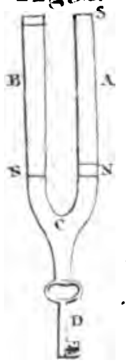

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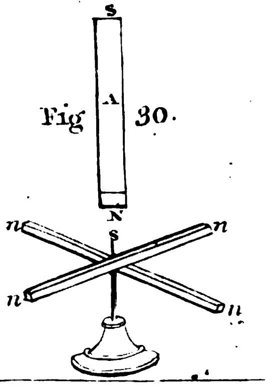

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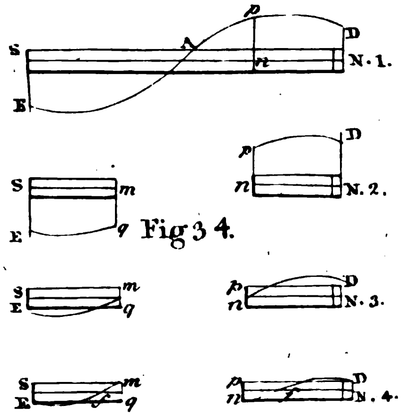

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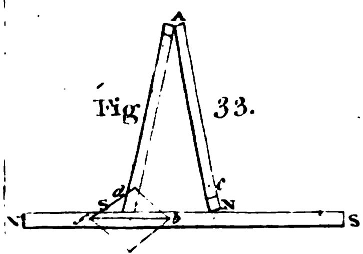

which it reflects on him. It ſurely requires no great powers of abſtraction to diſcover, that a coloured coat, bag-wig, and ſword, are not in themſelves more frivolous or contrary to nature, than a black coat and enormous peruke; and if the manners of a country have appropriated theſe different dreſſes to different ſtations in life, the individual muſt be actuated by a very abſurd kind of pride, who ſets up his own caprice againſt the public opinion.

As, when inveſted with the power to reſtrain within juſt limits the freedom of the preſs, it was his chief aim to encourage and extend that freedom; ſo, when raiſed to an office which gave him the unlimited power of iſſuing *lettres de cachet*, it was their total ſuppreſſion that became the earlieſt object of his *moſt ardent* zeal. Till that time *lettres de cachet*, being conſidered as a part of the general police, as well as of the royal prerogative, were iſſued not only at the will of the miniſter, but even at the pleaſure of a common clerk, or perſons ſtill more inſignificant. Maleſherbes began by relinquiſhing himſelf this abſurd and iniquitous privilege. He delegated the right to a kind of tribunal, compoſed of the moſt upright magiſtrates, whoſe opinion was to be unanimous, and founded upon open and well eſtabliſhed facts. He had but one more object to attain, and that was to ſubſtitute a legal tribunal in the place of that which he had eſtabliſhed; and this object he was upon the point of accompliſhing, when the intrigues of the court procured the diſmiſſion of Turgot; and Maleſherbes, in conſequence, reſigned on the 12th of May 1776. For this part of his conduct he is intitled to praiſe, which we feel not ourſelves inclined to withhold from his memory. Even M. Barruel admits, that he had many moral virtues, and that he diſplayed real benevolence when alleviating the rigours of impriſonment, and remedying the abuſe of *lettres de cachet*; but France, ſays he, ſhall nevertheleſs demand of him her temples that have been deſtroyed; for it was he who, above all other miniſters, abuſed his authority to eſtabliſh in that kingdom the reign of impiety.

After this epoch he undertook ſeveral journeys into different parts of France, Holland, and Switzerland, where he collected with zeal and taſte objects of every kind intereſting to arts and ſciences. As he travelled with the ſimplicity and economy of a man of letters, who had emerged from obſcurity for the purpoſe of making obſervations and acquiring knowledge, he by that means was enabled to reſerve his fortune for important occaſions, in which it might procure him information on intereſting ſubjects. He travelled ſlowly, and frequently on foot, that his obſervations might be the more minute; and employed part of his time in ſuitably arranging them. Theſe obſervations formed a valuable collection of intereſting matter relative to the arts and ſciences, but which has been almoſt totally deſtroyed by the fury of revolutioniſts, who have done as much prejudice to the intereſts of ſcience as of humanity.

Returning from his travels, Maleſherbes for ſeveral years enjoyed a philoſophic leiſure, which he well knew how to direct to uſeful and important objects. The two treatiſes which he compoſed in the years 1785 and 1786 on the civil ſtate of the proteſtants in France are well known. The law which he propoſed in theſe, was only preparatory to a more extenſive reform; and theſe treatiſes were to have been followed up by another work, the plan of which he had already laid down, when affairs growing too difficult to be managed by thoſe who held the reins of government, they were compelled to call him to their councils. They did not, however, aſſign him the direction of any department, and introduced him merely (as ſubſequent events have ſhewn) to cover their tranſactions under a popular name, and paſs them on the world as acts in which he had taken part. Maleſherbes accepted their overtures merely to ſatisfy the deſire he felt to reveal ſome uſeful truths; but it was not for that purpoſe that they had invited him to their councils. Thoſe who preſided at them took umbrage at his firſt efforts to call their attention to the voice of truth and wiſdom; and ſucceeded ſo well in their oppoſition, that he was reduced to the neceſſity of delivering in writing the counſel which he wiſhed to offer. Such was the origin of two treatiſes relative to the calamities of France, and the means of repairing them. He tranſmitted theſe treatiſes to the king, who never read them; nor was he ever able to obtain a private audience although a miniſter of ſtate.

Such is the account of his laſt conduct in office which is given by his friends; and as we have not read his treatiſes on the calamities of France, we have no right to controvert it. From his known principles, however, we are intitled to conclude, that his plans of reformation were ſimilar to thoſe of Neckar, the offſpring rather of a head teeming with viſionary theories, than of the enlightened mind of a practical ſtateſman, or the corrupt heart of a Jacobin conſpirator.

Perceiving the inutility of his endeavours, diſguſted with what he thought the repeated errors of the government, and deprived of every means of expoſing them, or preventing their fatal effects; after frequent ſolicitations, he at length obtained leave to retire. He repaired to his eſtate at Maleſherbes, and from that moment entirely devoted his time to thoſe occupations that had ever formed the chief pleaſure of his life. He paſſed the evenings and a great part of the night in reading and ſtudy.

In this tranquil ſtate he was paſſing the evening of his days amidſt his woods and fields, when the horrors of the Revolution brought him again to Paris. During the whole of its progreſs, he had his eyes conſtantly fixed on his unhappy ſovereign, and, ſubduing his natural fondneſs of retirement, went regularly to court every Sunday, to give him proofs of his reſpect and attachment. He impoſed it as a duty on himſelf to give the miniſters regular information of the deſigns of the regicide faction *; and when it was determined to bring the king to trial, he voluntarily offered to be the defender of his maſter, in his memorable letter of the 11th of December 1792, that eternal monument of his loyalty and affection. His offer was accepted; and he pleaded the cauſe of the monarch with a ſtrength of argument that nothing could have reſiſted but the bloodthirſty minds of a den of Jacobins. "What Frenchman (ſays a valuable writer), what virtuous man, of any country, can ever forget that affecting ſcene, when the reſpectable old man, penetrating, for the firſt time, into the priſon of the Temple, melted into tears, on finding himſelf preſſed in the arms of his king; and that ſtill more affecting ſcene, when, entruſted with the moſt agonizing commiſſion that a ſubject could poſſibly have to his ſovereign, he threw himſelf at the feet of the innocent victim, while, ſuffocated with his ſobs, his voice,

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* *Bertrand's Memoirs*, vol. iii. chap. 31.

till re-animated by the courage of the virtuous Louis, was inadequate to announce the fatal ſentence of death*.

Having diſcharged this painful and hazardous duty he once more returned to his country reſidence, and reſumed his tranquil courſe of life. But this tranquillity was of ſhort duration. About a twelvemonth afterwards, in the month of December 1793, three worthy members of the Revolutionary Committee of Paris came to reſide with him, his ſon-in-law, and his daughter, and apprehended the two latter as criminals. Left alone with his grandchildren, Maleſherbes endeavoured to conſole the reſt of his unfortunate family with the hopes which he himſelf was far from entertaining, when, the next day, the new formed guards arrived to apprehend him, and the whole of his family, even the youngeſt infants. This circumſtance ſpread a general conſternation throughout the whole department; for there was hardly a man in France, a few ex-jeſuits excepted, who did not revere the mild virtues of the laſt friend of the unfortunate king.

In this calamity Maleſherbes preſerved the undiſturbed equanimity of virtue. His affability and good humour never forſook him, and his converſation was as uſual; ſo that to have beheld him (without noticing his wretched guards), it ſeemed that he was travelling for his pleaſure with his neighbours and friends. He was conducted the ſame night to the priſon of the Madelonette with his grandſon Louis Lepelletier, at the ſame time that his other grandchildren were ſeparated into different priſons. This ſeparation proving extremely afflicting to him, he earneſtly ſolicited againſt it; and at length, on his repeated entreaties, they all met together once more at Port-Libre. They remained there but a ſhort period. The ſon-in-law of Maleſherbes, the virtuous Lepelletier Raſambo, the firſt of them who was arreſted, was ordered into another priſon, and ſacrificed a few days after. Maleſherbes himſelf, his daughter, his grand-daughter, and her huſband, were ſoon after all brought to the guillotine. They approached it with fortitude and ſerenity. It was then that his daughter addreſſed theſe pathetic words to Mademoiſelle Sombreuil, who had ſaved the life of her own father on the 2d of September: "You have had the exalted honour to preſerve *your* father—I have, at leaſt, the conſolation to die with *mine*."

Maleſherbes, ſtill the ſame, even to his laſt moments exhibited to his relations an example of fortitude. He converſed with the perſons that were near him without beſtowing the leaſt attention on the brutalities of the wretches who tied his hands. As he was leaving the priſon to aſcend the fatal cart, he ſtumbled againſt a ſtone, and made a falſe ſtep. "See (ſaid he ſmiling), how bad an omen! A Roman in my ſituation would have been ſent back again." He paſſed through Paris, aſcended the ſcaffold, and ſubmitted to death with the ſame unſhaken courage. He died at the age of 72 years, 4 months, and 15 days. He had only two daughters, and the ſon of one of them alone remains to ſucceed. From this account of Maleſherbes's behaviour at his laſt moments, we are inclined to believe that his intentions were better than ſome parts of his practical conduct; and we know, that having diſpelled the vain illuſions of philoſophiſm, he acknowledged his paſt errors; exclaiming, in the accents of grief, "That falſe philoſophy (to which I confeſs I was myſelf a dupe) has plunged us into the gulph of deſtruction, and, by an inconceivable magic, has faſcinated the eyes of the nation, and made us ſacrifice reality to a mere phantom. For the ſimple words *political liberty*, France has loſt that *ſocial freedom* which ſhe poſſeſſed in every reſpect, in a higher degree, than any other nation! How truly great did the king appear in his laſt moments! All their efforts to degrade him were vain; his unſhaken virtue triumphed over their wickedneſs. It is true, then, that religion alone transfuſes ſufficient courage into the mind of man, to enable him to ſupport, with ſo much dignity, ſuch dreadful trials †.

MALGUZZARY, in the language of Bengal, *payment* of revenue; the *revenue* itſelf.

MALPHAGHINO (John), otherwiſe called John de Ravenna, from the place of his birth, was born in the year 1352, of a family diſtinguiſhed neither by riches nor nobility. His father, however, committed him to the care of Donatus the grammarian, an intimate friend of Petrarch, who at that time taught the Latin tongue with great applauſe at Venice. Donatus thought he diſcovered ſuch happy diſpoſitions in young Malphaghino, that he recommended him to Petrarch, not only as an excellent aſſiſtant to facilitate his labours, by reading or tranſcribing for him, but as a youth of the moſt promiſing talents, and worthy of being formed under the inſpection of the greateſt man of the fourteenth century.

It appears from ſome of Petrarch's letters, for it is from theſe chiefly we can obtain information reſpecting John de Ravenna, that he fully anſwered the expectations formed of him; and that he even gained the favour and affection of his patron ſo much, that he loved him and treated him as if he had been his own ſon. In a letter to John de Certaldo (A), Petrarch highly extols him, not only for his genius and talents, but alſo for his prudent and virtuous conduct. "He poſſeſſes (ſays he) what is very rare in our times, a great turn for poetry, and a noble deſire to become acquainted with every uſeful and ornamental part of knowledge. He is favoured by the Muſes, and already attempts verſes of his own; from which one can foretel, that, if his life be ſpared, and if he goes on as hitherto, ſomething great may be expected from him."

Not long, however, after this panegyric was written, young Malphaghino conceived an inſuperable deſire to ſee the world; and, notwithſtanding all Petrarch's remonſtrances, perſiſted in his reſolution of quitting him. Petrarch's paternal care and regard for his pupil appear, on this occaſion, in the moſt favourable light, as may be ſeen in his letters to Donatus; and his whole behaviour, though the young man inſiſted on leaving him, without aſſigning a ſufficient reaſon for his precipitate and ungrateful conduct, does as much honour to his head as to his heart.

The precipitation with which John de Ravenna carried his plan into execution was not likely to make it anſwer his expectations. He departed without taking with him letters of recommendation which Petrarch offered him to his friends. He, however, purſued his journey over the Appenines, amidſt continual rain, giving out that he had been diſmiſſed by Petrarch; but, though he experienced from many a compaſſion to which he was not entitled by his conduct, he now began to awaken from his dream. He proceeded therefore to

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* *Clery's Journal*, p. 158—196.

† Bertrand's *Memoirs*, chap. 4.

(A) Better known under the name of *Boccaccio* or *Boccace*. Certaldo was the place of his birth.

Piſa, in order to procure a veſſel to carry him back towards Pavia: but being diſappointed, while his money waſted as much as his patience decreaſed, he ſuddenly reſolved to travel back acroſs the Appenines. When he deſcended into the Ligurian plains, he attempted to wade through a river in the diſtrict of Parma, which was much ſwelled by the rains; and being carried by the force of the ſtream into a whirlpool, he would have loſt his life, had he not been ſaved by ſome people who were accidentally paſſing that way. After eſcaping this danger, he arrived, pennyleſs and famiſhed, at the houſe of his former patron, who happened then not to be at home; but he was received and kindly entertained by his ſervants till their maſter returned.

Petrarch, by his intreaties and paternal admonitions, retained the young man at his houſe for about a year, and prevented him from engaging in any more romantic adventures; but, at the end of that period, his deſire for rambling again returned; and as Petrarch found that all attempts to check him would be fruitleſs, he gave him letters of recommendation to two of his friends, Hugo de St Severino and Franciſcus Brunus, at Rome. To the former of theſe, Petrarch ſays, "This youth of rare talents, but ſtill a youth, after propoſing to himſelf various plans, has at length embraced the nobleſt; and as he once travelled, he is now deſirous of doing ſo again, in order to gratify his thirſt of knowledge. He has, in particular, a ſtrong inclination for the Greek language; and entertains a wiſh which Cato firſt conceived in his old age. This wiſh I have endeavoured for ſome years to ſubdue; ſometimes by intreaties, at other times by admonition; ſometimes by repreſenting how much he is ſtill deficient in the Roman language; and ſometimes by laying before him the difficulties which muſt attend him in his journey, eſpecially as he once before left me, and by want was obliged to return. As long as that unfortunate excurſion was freſh in his memory he remained quiet, and gave me hopes that his reſtleſs ſpirit could be overcome and reſtrained. But now, ſince the remembrance of his misfortunes is almoſt obliterated, he again ſighs after the world; and can be retained neither by force nor perſuaſion. Excited by a deſire which betrays more ardour than prudence, he is reſolved to leave his country, friends, and relations, his aged father, and me whom he loved as a father, and whoſe company he preferred to a reſidence at home, and to haſten to you whom he knows only by name. This precipitation even has an appearance of prudence. The young man firſt wiſhed to viſit Conſtantinople; but when I told him that Greece, at preſent, is as poor as it was formerly rich in learning, he gave credit to my aſſertion, and at any rate altered his plan, which he could not carry into execution. He is now deſirous of traverſing Calabria, and the whole coaſt of Italy, diſtinguiſhed formerly by the name of Magna Græcia, becauſe I once told him that there were in that quarter ſeveral men well ſkilled in the Greek language, particularly a monk, Barlaam, and one Leo, or Leontius, with whom I was intimately acquainted, and of whom the firſt had been ſome time my ſcholar. In conſequence of this propoſal, he begged me to give him a recommendatory letter to you, as you have conſiderable influence in that part of the country. This requeſt I granted, in hopes that the young man, by his genius and talents, will afford you ſatisfaction equal to the ſervice which you may render to him." In his letter to Brunus, Petrarch expreſſes himſelf as follows: "He is a young man who wiſhes to ſee the world as I formerly did; but I never reflect on it without horror. He is deſirous of ſeeing Rome; and this deſire I cannot condemn, as I myſelf have ſo often viſited that city, and could ſtill reviſit it with pleaſure. I ſuſpect, however, that he will venture on a more extenſive ocean, and that he imagines to find a fortune where he will, perhaps, meet with a ſhipwreck. At any rate, he is deſirous, he ſays, of putting his fortune to a trial. I wiſh it may be favourable; ſhould it be adverſe, he is ſtill at liberty to return to my peaceful, though ſmall, haven; for I hang out a light, during the day as well as the night, to guide thoſe who quit me through youthful folly, and to enable them to find their way back. The ardour by which he is impelled muſt not be aſcribed ſo much to him as to his age, and is in itſelf commendable. If I am not much deceived, the young man loves me and virtue in general. He is unſteady, but modeſt; and deſerves that all good men ſhould contribute to his proſperity as far as they can."

From the letters of Petrarch, there is reaſon to believe, that John de Ravenna lived with him only about three years in all; and that he had not attained to the full age of manhood when he left him. It appears alſo, for this circumſtance is very obſcure, that after he quitted him, he wandered about a conſiderable time before he was ſo fortunate as to meet with a protector and patron, at whoſe houſe, as he wrote to Petrarch, he at laſt found a permanent aſylum. How long he remained with his patron, whom ſome believe to have been Cardinal Philip, and what happened to him till the death of Petrarch in 1374, and for ſome years after, is unknown. The literary monuments of the fourteenth and fifteenth centuries ſay nothing farther of him till his appearance at Padua; where, according to the teſtimony of Sicco (B), one of the moſt celebrated of his ſcholars, he not only taught the Roman Eloquence, but alſo the ſcience of moral philoſophy, with ſuch ſucceſs and applauſe, and improved his ſcholars ſo much by his life and example, that, according to univerſal opinion, he far excelled all the profeſſors of thoſe ſciences who had ever before appeared. That he was here of conſiderable ſervice in reviving the ſtudy of the Latin language, and of the works of the ancient Romans, was acknowledged by all his ſcholars, and is confirmed by the following teſtimony of Blondus (C).

"About the ſame period, Ravenna produced that learned

(B) Adoleſcens tum ego poetas, et inſtituta Tullii audiebam. Legebat tunc hac in civitate Padua, literarum nutrice, *Johannes Ravennas* vir et ſanctimonia morum, et ſtudio iſto excellens, atque ſi poteſt ſine invidia, dici ceteris, qui magiſtri artis hujus in terra Italia uſquam degerent et doctiſſimi haberentur, quantum recordari videor, omnium judicio præferendus. Hoc namque a præceptore non eloquentia modo, quam ex ordine legerit, ſed mores etiam, ac quædam bene honeſteque vivendi ratio cum doctrina tum exemplis diſcebatur.—*Sicco Polentonus*, Ap. Mehus, l. c. p. 139.

(C) Blondi Flavii Forlivienſis Italia illuſtrata. Bas. 1559. fol. p. 346.

learned grammarian and rhetorician Johannes, of whom Leonardus Aretinus uſed to ſay, that he firſt introduced into Italy, after a long period of barbariſm, the ſtudy of the Latin language and eloquence, now ſo flouriſhing; a circumſtance which deſerves to be enlarged on in the preſent work. Thoſe well acquainted with Roman literature know, that after the periods of Ambroſe, Jerom, and Auguſtine, there were none, or very few, who wrote with any elegance, unleſs we add to theſe good writers, St Gregory, the venerable Bede, and St Bernard. Francis Petrarcha was the firſt who, with much genius, and ſtill greater care, recalled from the duſt the true art of poetry and of eloquence. He did not attain to the flowers of Ciceronian eloquence, with which many are adorned in the preſent century; but this was owing rather to a want of books than of talents. Though he boaſted of having found at Vercelli Cicero's letters to Lentulus, he was unacquainted with the books of that great Roman *De Oratore*, Quintilian's Inſtitutes, the *Orator*, the *Brutus*, and other writings of Cicero. John de Ravenna was known to Petrarch both in his youth and in his old age. He was not more converſant with the ancients than Petrarch; and, as far as I know, left no works behind him. By his excellent genius, however, and, as Leonardus Aretinus ſays, by the particular diſpenſation of God, he was the preceptor of this Leonardus, of Petrus Paulus Vergerius, of Annebonus de Padua, of Robert Roſſi, of James Angeli of Florence, of Poggius and Guarino of Verona, of Victorinus, Sicco, and other men of leſs note, whom he incited to the ſtudy of better knowledge, and to imitate Cicero, if he could not form them or inſtruct them completely.

" About the ſame time, Manuel Chryſoloras, a man as virtuous as learned, came from Conſtantinople to Italy, and inſtructed in the Greek language, partly at Venice and partly at Florence and Rome, all the before mentioned ſcholars of John de Ravenna. After he had continued this inſtruction for ſome years, thoſe unacquainted with the Greek language, and the ancient Greek writers, were conſidered in Italy as more ignorant than thoſe unacquainted with the Latin. A great many young men and youths were inflamed with an enthuſiaſtic deſire for the works of the ancient Greeks and Romans. At the time of the council of Conſtance, in the beginning of the fifteenth century, many of my countrymen endeavoured, by ſearching the neighbouring cities and convents, to diſcover ſome of the Roman manuſcripts which had been loſt. Poggius firſt diſcovered a complete copy of Quintilian, which was ſoon followed by the letters of Cicero to Atticus. As our youth applied to the ſtudy of theſe works with the utmoſt diligence, that celebrated grammarian and rhetorician Caſparinus de Bergamo, opened a ſchool at Venice, ſuperior to the former, and in which young perſons were encouraged to ſtudy the ancient languages and writers. About the ſame time flouriſhed Petrus Paulus Vergerus, Leonerdus Aretinus, Robert Roſſi, James Angeli, Poggius, and Nicolaus de Medici, whom Aretin had long inſtructed. Guarinus alſo had begun to inſtruct many at Venice, and Victorinus at Mantua, when Philip III. Duke of Milan, recalled Caſparinus as his ſubject, from Venice to Padua and Milan. The increaſing ſtudy of ancient literature was much promoted by Gerard Landriano biſhop of Lodi, diſcovering under ſome ruins an old copy of Cicero, written in characters ſcarcely legible, which, among other rhetorical writings of that great Roman, contained the whole books *De Oratore*, with his *Brutus* and *Orator*. This ſaved Caſparinus the trouble of ſupplying the books of Cicero *De Oratore*, as he had attempted to ſupply the works of Quintilian. As no one was found in all Milan who could read this old manuſcript of Cicero, an ingenious young man of Verona, named Caſmus, was ſo fortunate as firſt to tranſcribe the books *De Oratore*, and to fill all Italy with copies of a work which was univerſally ſought for with the utmoſt avidity. I myſelf, in my youth, when I went to Milan on the buſineſs of my native city, tranſcribed, with as much ardour as ſpeed, the *Brutus* of Cicero, and ſent copies of my tranſcription to Guarinus at Verona, and to Leonard Juſtiniani at Venice; by which means this work was ſoon diſperſed all over Italy. By theſe new works eloquence acquired new fire; and hence it happens, that in our age people ſpeak and write better than in the time of Petrarch. The ſtudy of the Greek language, beſides the abundance of new and uſeful knowledge which it diſcloſed, was attended with this great advantage, that many attempted to tranſlate Greek works into Latin, and thereby improved their ſtyle much more than they could have done without that practice. After this period, ſchools for teaching the ancient languages increaſed in Italy, and flouriſhed more and more. Moſt cities had ſchools of this kind; and it gives one pleaſure to obſerve, that the ſcholars excelled their maſters, not only when they left them, but even while they were under their tuition. Of the ſcholars of John de Ravenna, two of the oldeſt, Guarinus and Victorinus, the former at Venice, and the latter at Mantua, Verona, Florence, and Ferrara, inſtructed an immenſe number of pupils; and among theſe, the Princes of Ferrara and Mantua. George of Trebiſonde, when he lectured at Rome, had for his auditors, beſides Italians, many French, Spaniards, and Germans, among whom ſometimes there were men of rank and eminence. Franciſcus Philelphus, who had been taught at Conſtantinople by Chryſoloras himſelf, inſtructed a great many young men and youths in the Greek and Latin languages at Venice, Florence, Siena, Bologna, and, laſt of all, at Milan." In the above quotation, the ſhare which John de Ravenna had in reviſing and diffuſing a knowledge, not only of the Roman, but alſo of the Grecian literature, is ſo clearly repreſented, that no farther teſtimony is neceſſary to eſtabliſh his claim to celebrity.

After John de Ravenna had taught at Padua, he removed for the like purpoſe to Florence; where, as appears, he inſtructed young people for ſome time, without being expreſsly invited by the government, and without being publicly paid for his labours. In the beginning of his reſidence at Florence, he ſeems to have been recommended by Colucius to the learned Charles de Malateſta. " There lives here at preſent (ſays Colucius, in one of his letters) a teacher of great merit, John de Ravenna.—He is (continues he) of mature age; irreproachable in his manners, and ſo diſpoſed in general, that if you receive him, as I hope and wiſh, among the number of your intimate friends, you will find him an agreeable and incomparable aſſiſtant to you in your labours and ſtudies. What can be more deſirable to you than to poſſeſs a man who will lucubrate and labour for you? and who, in a ſhort time, can communicate to you what you could not obtain by your own exertions without great difficulty. I do not know whether you will find his like in all Italy; and I therefore wiſh, that, if you confide in my judgment, you will receive John de Ravenna in the room of your late learned friend James de Alegretti." It is not known whether John de Ravenna went to reſide with Malateſta or not. It is, however, certain, that the former, in 1397 (the ſame year in which Manuel Chryſoloras came to Florence), was invited thither by the magiſtrates of that city, with the promiſe of an annual ſalary, to inſtruct young people in the Roman language and eloquence; that John de Ravenna, at the period when he entered into this honourable engagement, was 45 years of age; and that the ſcholars of John de Ravenna were, at the ſame time, ſcholars of Chryſoloras. Saluratus Colucius, in all probability, was the cauſe of this invitation, as he was acquainted with the ſervices of John de Ravenna, and knew how to appreciate them. "We know (ſays he, in one of his letters to John de Ravenna), and all who reſpect you know alſo, that none of the moderns, or even ancients, approached ſo near to Cicero as you; and that to the moſt wonderful beauty and powers of ſpeech, you join the deepeſt knowledge." John de Ravenna, like Chryſoloras, and moſt of the teachers of the Greek and Roman languages in the beginning of the fifteen century, was, no doubt, engaged at firſt only for a few years; when theſe were elapſed, the engagement was renewed, perhaps for the laſt time, in 1412, and he was bound, beſides teaching the Roman eloquence, to read publicly, and explain in the cathedral, on feſtivals, the poems of Dante. John de Ravenna did not long ſurvive the above renewal of his engagement; for an anonymous writer, who, in 1420, finiſhed *A Guide to Letter-writing, according to the Principles of John de Ravenna*," ſpeaks of his preceptor as of a man not then in exiſtence.

MALT. See Brewing (*Encycl.*), where a full account is given of Sir Robert Murray's method of malt-making, together with ſome valuable obſervations on malt by Mr Richardſon of Hull. In a late edition of this latter gentleman's *Theoretic Hints on Brewing*, we are told, that Mr Edward Rigby of Norwich is of opinion, that the mere exſiccation of corn is not the only object obtainable by drying it on the kiln, but that ſome portion of the ſaccharum of malt is the effect of that proceſs. "The operation of kiln drying the malt (ſays Mr Rigby) is as follows:—The grain is ſpread thick upon a floor made of flat bricks (*tiles*), or iron plates, which are full of perforations; immediately under this floor is the oven or furnace, in which is a large fire made of *coaks*, cinders, or, in ſome places, billet wood; a current of air, at the mouth of the furnace, keeps up the combuſtion of the coaks, and the air which is phlogiſticated by their burning, and which, in a common fire place, riſes up the chimney, paſſes, in this inſtance, through the apertures in the floor, and penetrates the whole ſtratum of malt before it can paſs into the external air. Under theſe circumſtances, it is evident, that the interſtices of the malt muſt be filled with phlogiſtic air; and as the grain uſually remains in this ſituation about two days, it is obvious, that if it have the power of abſorbing phlogiſton, it certainly muſt do it when ſo long in contact with it. And that the malt does really imbibe ſome of this principle, is not only probable on the general ground of the truth of the preceding theory, but, I believe, it will be found, that the phlogiſticated air which riſes from the burning ſubſtances underneath, is corrected in paſſing through the malt; for without its being meliorated by this or ſome other cauſe, it is evident that the air in the kiln-chamber, more eſpecially the lower ſtrata of it, muſt be noxious, and probably even ſo much ſo as to be unfit for reſpiration and combuſtion. But ſo far from this being the caſe, I am informed, that workmen will lie and ſleep many hours on the malt in this ſituation without ſuffering any inconvenience. And after mentioning this, it is ſcarcely neceſſary to add, that I find alſo, by experiment, that a candle will burn perfectly well in the air which is immediately on the ſurface of the malt.

"Were heat alone ſufficient for the purpoſe of completing the operation of malting, it certainly might be applied in a much more cheap way than is at preſent done; for the floor on which the grain is laid might, unqueſtionably, be heated equally without there being perforations in it, as with them. In which caſe, one kind of fuel would be as good as another; and, conſequently, the preſent expence of previouſly burning the coals, to convert them into coaks or cinders, might be ſaved.

"But, admitting that the application of phlogiſton to the malt, as well as heat, is requiſite in this operation, the neceſſity of theſe perforations becomes evident, and alſo the propriety of previouſly burning the coals in ſuch a way, that all the water, and thoſe other heterogeneous particles which compoſe ſmoke and ſoot, may be diſſipated; for theſe, merely as ſuch, would obviouſly contribute little to the phlogiſtication of the malt, and would evidently impart ſome offenſive flavour, if not ſome obnoxious quality to it.

"Reaſoning from the above premiſes (Mr Rigby concludes), it would ſeem, that as all the farinaceous parts of the barley are ſeldom diſſolved in brewing, and the grains which are left have uſually the diſpoſition to become ſour, thereby manifeſting ſome of the acid principle to be ſtill exiſting in them, it is not improbable but ſome further ſaccharine matter might be obtained from the grain by another expoſure to phlogiſticated air, or, in other words, by being once more laid on the kiln."

This is indeed ſo far from being improbable, that we think it muſt infallibly be the caſe. Sugar, it is well known, conſiſts of oxygen, hydrogen, and carbon (ſee Chemistry in this *Supplement*, n° 466.); but from the diſpoſition of the grains to become ſour, it is plain, that after the proceſs of brewing they ſtill retain much oxygen; and the azotic gas, which is here called phlogiſticated air, there is every reaſon to believe contains both hydrogen and carbon. Theſe, therefore, uniting with the oxygen of the grains, muſt make an addition to the ſaccharine matter. This has, indeed, been found to be the fact by Mr Richardſon, who, in conſequence of Mr Rigby's ſuggeſtion, was induced to brew a ſmall brewing of malt, of ten quarters only, and ſtopping the proceſs when, according to his general practice, one extract was ſtill due, he ordered the grains to be laid upon one of his malt-kilns, and cinders to be applied the ſame as for drying of malt. This was continued for two days and a half, when the grains, being perfectly dried, were put into ſacks, and, when cold, returned again into the maſh-tun. The event, in ſome meaſure, juſtified Mr

Rigby's expectation; for the produce of fermentable matter was conſiderably more than he had reaſon to conclude would have been the caſe, had the extract been made in immediate ſucceſſion, as it would have been in the ordinary courſe of his practice. He attempts, indeed, to account for it in a way very different from ours; but though we have the higheſt confidence in Mr Richardſon as an experienced brewer, we muſt ſometimes beg leave to think for ourſelves as chemiſts. Like a man of ſenſe, however, and a man of ſcience, he ſays, "I am ſo well ſatisfied with the event of this experiment, that I ſhall probably be inclined, on ſome future occaſion, to repeat it, in various ſtages of the proceſs. The fine lively froth on the ſurface of the wort, in the underback, added to its tranſparency and good flavour, are circumſtances which induce me to thank Mr Rigby for the hint, which, it is not improbable, may be applied to ſome uſeful purpoſe, in certain ſituations which ſometimes occur in the brewing trade."

MAMMALUKES, Mamalucs, *Mameloucs*, or *Mamluks*, were a dynaſty that reigned for a conſiderable time in Egypt, and of which ſome account has been given in that article (*Encycl.*). A fuller account of them muſt, however, be acceptable to our readers, as, ſince the expedition of Buonaparte, they have attracted the attention of all Europe.

Antijacobin Review, n° 12. and *Brown's Travels*.

They were firſt introduced into Egypt, as we have already obſerved, by Saladine, who, when he had it in contemplation to beſiege Jeruſalem, very naturally endeavoured to collect the moſt forcible means to accompliſh ſo deſirable an end; and, in conſequence, obſerving that the ancient inhabitants of Egypt were, from their effeminate mode of education, and the quiet and tranquil habits of their lives, much fitter for thoſe occupations in which they delighted, namely, the arts, merchandize, and mechanics, than military tactics and military toil, he reſolved, as little as poſſible, to employ or depend upon them.

This reſolution ſtimulating him to procure a hardier race of ſoldiers, he therefore commiſſioned agents to treat with the Circaſſians, by the Lake of Mæotis, near Tawrica Cherſoneſas, whence, about the year 1175, they purchaſed more than a thouſand ſlaves. Men inured to hardſhip, nurtured in the lap of toil and danger, and bred from their infancy to war, which was to them rather an inſtinct than a ſcience, as the continual incurſions of the Tartars rendered ſelf-defence, in their ſituation, abſolutely neceſſary.

Theſe ſlaves Saladine trained to military diſcipline, and, at the ſame time that he made them renounce Chriſtianity, had them inſtructed in the Mahometan religion; and although he prohibited them from marrying, he allowed them an unbounded licence with reſpect to deſultory gallantry. What progreſs they made in the doctrines of the Alcoran, whether the tenets of that ſacred volume effectually eradicated all their firſt principles, is uncertain; but it is certain, that in time they became excellent ſoldiers, and that the military glory of Saladine, which was feebly ſupported by the native Egyptians, expanded in the hands of the Mameloucs, who extended their conqueſts on every ſide, until, pervading the Holy Land, they entered in the plain of Aſkelon.

Theſe Mameloucs, who were continually adding to their numbers, in proceſs of time became naturalized to the country; and, as it has been obſerved, they excelled the Egyptians in ſtrength of body, in military diſcipline, in their ſkill in horſemanſhip, and in courage; ſo they, by the liberality of their generals, and the plunder of cities and provinces, alſo excelled them in wealth. In fact, their mode of education fitted them for the moſt dangerous and adventurous enterpriſes, and, from being the ſlaves, enabled them in time to become the maſters of even the Turks, by whom they had originally been purchaſed.

After the death of Saladine, who left the kingdom to his brother, they roſe to ſtill greater importance than they had acquired during his reign, and continued, if not abſolutely to govern, yet, like the Roman ſoldiers in the time of Pertinax, Alexander, and Valerian, to awe the monarch.

This influence continued through the reigns of five ſucceſſive Caliphs, until that of Melachſala, the laſt of the poſterity of Saladine, who being at war with the Arriſtians, and, at the ſame time, wiſhing to repreſs the enormous power of the Mameloucs, purchaſed ſlaves from all the ſurrounding countries, whom, in imitation of his anceſtor, he armed and appointed to defend his dominions. The event of this meaſure was exactly what might have been expected. Melachſala was, in conſequence of a conſpiracy betwixt his new and his old ſoldiers, ſlain; and Turquemenus, the leader of this mutiny and rebellion, hailed by the title of Great Sultan of Egypt. With him began the government of the Mameloucs, about the year 1250; which had the next year gathered ſuch ſtrength, that it was thought neceſſary, in order to repreſs thoſe exuberances to which new formed governments are liable, and bring it nearer to a ſyſtem, to cauſe the following articles, in the form of a charter, to be ſubſcribed to by their principal leaders, as an act of the whole people:—"1ſt, That the Sultan ſhould be choſen from the body of Mameloucs; 2dly, That none ſhould be admitted into the order that were by birth either Jews or Turks, but only Chriſtian captives; 3dly, That the native Egyptians ſhould not be permitted to uſe, or have, any weapons, except the inſtruments of agriculture."

Turquemenus, as is frequently the practice with thoſe that experience a ſudden elevation, endeavoured to kick down the ladder by which he had been raiſed; or, in other words, his carriage was ſo haughty and diſdainful to his former companions, that he was by them, or rather by one of them named Clotho, ſuddenly ſlain; for which the murderer was rewarded with his ſceptre. After him ſucceeded a long race of princes, many of whom were as eminent for their talents as for their valour; among whom, the name of Caitbeius has been tranſmitted to us as that of the greateſt ſtateſman and general of his age; but, as every one who conſiders the *materials* of which the government was compoſed, muſt rather wonder that it exiſted ſo long, than that it ſhould, through almoſt the whole courſe of its operation, be expoſed to all the various evils and diſtreſſes ariſing from a long train of ſedition and tumults, ſo he muſt lament that it ſhould expire in the reign of one of their wiſeſt and beſt monarchs: yet it is ſome conſolation to reflect, that Campſon, the laſt Sultan of the Mameloucs, was not *murdered by his own ſubjects*, but having for many years governed the kingdoms of Egypt, Judea, and Syria, in a manner that has excited the praiſe of the hiſtoric pen, he, oppreſſed with age and diſeaſe, and encumbered with his armour, ſunk upon the field of battle, and, with his laſt breath, yielded the victory to the fortunate Selim.

With this monarch, who expired January 20, 1516, ended the government of the Mameloucs, after it had continued 276 years; for although an attempt was made by Tomumby to get himſelf declared Sultan, in which attempt he actually ſucceeded ſo far as to be inveſted with the title, yet he was ſoon after defeated by the victorious Selim. He was then forſaken by his troops, taken and executed; while the Mameloucs, broken and diſperſed, it was the policy of Selim to rally, and, by offers too tempting to be by them refuſed, engage in his ſervice. The uſe of theſe ſoldiers ſoon became ſufficiently apparent to the Turkiſh Emperors, to ſtimulate them to augment their number, enlarge their ſphere of action, and combine them cloſer to the ſtate, by the allowance of ſtill greater privileges and advantages than they had before enjoyed.

The Beys were ordained to be choſen from among them; and the Paſha, or chief governor for the Porte, was to ſhare his power with thoſe Beys, and even to continue in office no longer than ſhould be agreeable to their collective will. At firſt the power of the Paſha was very extenſive; but, by the intrigues and ambition of the Beys, it has been reduced almoſt to a cypher. It was rather of a civil than military nature. He was always preſident of the Divan, which was held in the caſtle where he reſided. But that council now commonly meets in the palace of one of the chief Beys, except when a firman or mandate is received from Conſtantinople, when the Beys are ſummoned to the caſtle, to hear the commands of the Porte. The few who attend, as ſoon as the reading is finiſhed, anſwer, as is uſual, "*Eſmana wa taana*," "We have heard, and we obey." On leaving the caſtle, their general voice is "*Eſmana wa awſina*," We have heard, and ſhall diſobey."

In the year 1791, Salah Aga, a ſlave of Murad Bey, was deputed from the government of Egypt to negociate their peace with the Porte. He carried preſents of horſes, rich ſtuffs, &c. A ſpontaneous tribute, which the Porte was in no condition to enforce, implied obligation on the part of the latter. He was well received, and afterwards was appointed *Waquil es Sultan*, agent or attorney to the Sultan in Cairo. It is probable, this office was given him to incline him to ſecond the efforts of the Court in diſuniting the Beys; but it was ineffectual. Theſe had formerly experienced the evils of diviſion, and now were united by common intereſt, grown rich, and well provided with ſlaves; ſo that no tribute has ſince that time found its way to Conſtantinople.

The Mameloucs remain, as they have ever been, military ſlaves, imported from Georgia, Circaſſia, and Mingrelia. A few have been priſoners, taken from the Auſtrians and Ruſſians, who have exchanged their religion for an eſtabliſhment. The Beys give general orders to their agents at Conſtantinople, to purchaſe a certain number every year; and many are brought to Egypt by private merchants on ſpeculation. When the ſupply proves inſufficient, or many have been expended, black ſlaves from the interior of Africa are ſubſtituted, and, if found docile, are armed and accoutred like the reſt.

Particular attention is paid to the education of theſe favoured ſlaves. They are inſtructed in every exerciſe of agility or ſtrength, and are, in general, diſtinguiſhed by the grace and beauty of their perſons. The gratitude of the diſciples is equal to the favour of their maſters, whom they never quit in the hour of danger. If they have a diſpoſition for learning, they are taught the uſe of letters, and ſome of them are excellent ſcribes; but the greater part neither can read nor write. A ſtriking example of which deficiency is obſervable in Murad Bey himſelf.

The inferior Mameloucs conſtantly appear in the military dreſs, and are commonly armed with a pair of piſtols, a ſabre, and a dagger. They wear a peculiar cap of a greeniſh hue, around which is wreathed a turban. The reſt of their dreſs reſembles that of other Mohamedan citizens, and is reſtricted to no particular colour; but another ſingularity is, their large drawers of thick Venetian cloth, of a crimſon colour, to which are attached their ſlippers of red leather. On horſeback they add to their arms a pair of large horſe piſtols, and the dubbus or battle axe. In battle, many of them wear an open helmet, and the ancient ring armour of interwoven links of ſteel, worn under part of their dreſs, and thus concealed. Theſe are dear; ſometimes coſting 500 piaſtres, or about L. 40. Some of them are made at Conſtantinople, others in Perſia. Their horſes are of the fineſt Arabian breed, and are often purchaſed at three or four purſes, L 150 to L. 200 ſterling.

They have no pay, as they eat at a table in the houſe of their maſter the Bey, Caſhef, or other officer. Any military officer may purchaſe a ſlave, who becomes, *ipſo facto*, a Mamelouc. The name, from *malek*, to poſſeſs, implies merely a perſon who is the property of another. After a proper education, the candidate thus conſtituted a Mamelouc, receives a preſent of a horſe and arms from his maſter, together with a ſuit of clothes; which is renewed every year in the month Ramadan. The generoſity of their maſters, and rewards or extortions from others, afford them ſupplies of money, either for avarice or debauchery. Some of them, admitted to peculiar favour by the Beys, as chaſnadars, or purſe-bearers, &c. acquire great wealth. They are rather gay and thoughtleſs than inſolent, fond of ſhow, and unprincipled in their means of acquiring it. They ſeldom marry till they acquire ſome office.

Though born of Chriſtian parents, they ſeem highly ſatisfied with their condition, which they have been known to refuſe to exchange for freedom. The majority are regarded by the Arabs as little ſtrict in the principles or duties of Mohamediſm. It is worthy of remark, that though the Mameloucs, in general, be ſtrong and perſonable men, yet the few who marry very ſeldom have children. As the ſon, even of a Bey, is not honoured with any particular conſideration, the women, perhaps, procure abortions. Of eighteen Beys, with whoſe hiſtory Mr Browne was well acquainted, two only had any children living.

Hardy, capable of every fatigue, of undaunted courage, and eminent ſkill in horſemanſhip and the uſe of the ſabre, the Mameloucs may be regarded as by far the beſt troops in the Eaſt. But in a regular battle, conducted by manœuvres, and large or rapid movements, they are equally inferior to European troops.

Being diſtinguiſhed by favouritiſm or merit, the Mameloue becomes a Caſhef, and in time a Bey. The chief cauſe of preference ariſes from political adherence to ſome powerful leader.

The government of Cairo, and Egypt, in general, is veſted in 24 Beys; each of whom is nominally choſen by the remaining 23, but, in fact, appointed by one of the moſt powerful. The Yenk-tchery, Aga, and ſeveral other officers, are enumerated among the 24 Beys.

Beſides being governors of certain diſtricts of Egypt, ſeveral of the Beys receive other dignities from the Porte: Such are the Shech el Bellad or governor of the city; the Defterdar, or accountant-general; the Emir el Hadj, or leader of the ſacred caravan; and the Emir es Said, or governor of the Upper Egypt. Theſe two laſt offices are annual. Theſe officers have alſo revenues allotted them by the Porte, ill defined, and liable to much abuſe.

Of the other Beys, each appoints all officers and governors within his diſtrict, putting into it ſome ſlave of his own, who is compelled to render an account of the receipts, of which a great part paſſes to ſupport the grandeur of his maſter. An opulent Bey may have from 600 to 1000 purſes annually; the revenue of Murad Bey more than doubles that ſum. The inferior Beys may have 300 purſes, or L. 15,000.

Every Bey ſits in judgment on caſes of equity. Theſe perſonages are very obſervant of their reſpective juriſdictions; and no Bey will impriſon a man liberated by another. Though ſometimes too impetuous, they nevertheleſs diſplay great acuteneſs and knowledge of characters. This government, at leaſt, poſſeſſes every advantage of publicity, as every Bey is a magiſtrate.

MAN, has been conſidered in a great number of particulars under the title MAN (*Encycl.*); but a reference was made from that article to the article *VARIETIES of the Human Species*, which was, after all, omitted entirely.

Perhaps enough has been ſaid on the varieties of the human ſpecies in the articles COMPLEXION and NEGRO (*Encycl.*); but as infidel ignorance is perpetually pretending, that the diminutive Icelanders, the ugly Eſquimaux, the woolly-headed Negro, and the copper-coloured American, could not have deſcended from one original pair, either of European complexion or of Hindoo ſymmetry—it may not be improper, in this place, to ſhew the weakneſs of this popular objection to the Moſaic hiſtory of the origin of man. This has been done in ſo ſatisfactory a manner by Profeſſor Blumenbach, that we have nothing to do but lay his obſervations before our readers, convinced, as we are, that they are intelligible to every capacity, and that they will carry conviction to all who are not the ſlaves of prejudice.

Phil. Mag. vol. iii. p. 284.

"Some late writers on natural hiſtory (ſays the Profeſſor) ſeem doubtful whether the numerous diſtinct races of men ought to be conſidered as mere varieties, which have ariſen from degeneration, or as ſo many ſpecies altogether different. The cauſe of this ſeems chiefly to be, that they took too narrow a view in their reſearches; ſelected, perhaps, two races the moſt different from each other poſſible, and, overlooking the intermediate races that formed the connecting links between them, compared theſe two together; or, they fixed their attention too much on man, without examining other ſpecies of animals, and comparing their varieties and degeneration with thoſe of the human ſpecies. The firſt fault is, when one, for example, places together a Senegal negro and an European Adonis, and at the ſame time forgets that there is not one of the bodily differences of theſe two beings, whether hair, colour, features, &c. which does not gradually run into the ſame thing of the other, by ſuch a variety of ſhades, that no phyſiologiſt or naturaliſt is able to eſtabliſh a certain boundary between theſe gradations, and conſequently between the extremes themſelves.

"The ſecond fault is, when people reaſon as if man were the only organiſed being in nature, and conſider the varieties in his ſpecies to be ſtrange and problematical, without reflecting that all theſe varieties are not more ſtriking or more uncommon than thoſe with which ſo many thouſands of other ſpecies of organiſed beings degenerate, as it were, before our eyes."

As what we have ſaid under the articles COMPLEXION and NEGRO may be ſufficient to warn mankind againſt the firſt error, and at the ſame time to refute it, we haſten to refute the ſecond by our author's compariſon between the human race and that of ſwine.

"More reaſons (ſays he) than one have induced me to make choice of ſwine for this compariſon; but, in particular, becauſe they have a great ſimilarity, in many reſpects, to man: not, however, in the form of their entrails, as people formerly believed, and therefore ſtudied the anatomy of the human body purpoſely in ſwine; ſo that, even in the laſt century, a celebrated diſpute, which aroſe between the phyſicians of Heidelberg and thoſe of Durlach, reſpecting the poſition of the heart in man, was determined, in conſequence of orders from government, by inſpecting a ſow, to the great triumph of the party which really was in the wrong. Nor is it becauſe in the time of Galen, according to repeated aſſertions, human fleſh was ſaid to have a taſte perfectly ſimilar to that of ſwine; nor becauſe the fat, and the tanned hides of both, are very like to each other; but becauſe both, in regard to the economy of their bodily ſtructure, taken on the whole, ſhew unexpectedly, on the firſt view, as well as on cloſer examination, a very ſtriking ſimilitude.

"Both, for example, are domeſtic animals; both *omnivora;* both are diſperſed throughout all the four quarters of the world; and both conſequently are expoſed, in numerous ways, to the principal cauſes of degeneration ariſing from climate, mode of life, nouriſhment, &c.; both, for the ſame reaſon, are ſubject to many diſeaſes, and, what is particularly worthy of remark, to diſeaſes rarely found among other animals than men and ſwine, ſuch as the ſtone in the bladder; or to diſeaſes excluſively peculiar to theſe two, ſuch as the worms found in meaſled ſwine.

"Another reaſon (continues he) why I have made choice of ſwine for the preſent compariſon is, becauſe the degeneration and deſcent from the original race are far more certain in theſe animals, and can be better traced, than in the varieties of other domeſtic animals. For no naturaliſt, I believe, has carried his ſcepticiſm ſo far as to doubt the deſcent of the domeſtic ſwine from the wild boar; which is ſo much the more evident, as it is well known that wild pigs, when caught, may be eaſily rendered as tame and familiar as domeſtic ſwine: and the contrary alſo is the caſe; for if the latter by any accident get into the woods, they as readily become wild again; ſo that there are inſtances of ſuch animals being ſhot for wild ſwine; and it has not been till they were opened, and found caſtrated, that people were led to a diſcovery of their origin, and how, and at what time, they ran away. It is well aſcertained, that, before the diſcovery of America by the Spaniards, ſwine were unknown in that quarter of the world, and that they were afterwards carried thither from Europe. All the varieties, therefore, through which this animal has ſince degenerated, belong, with the original European race, to one and the ſame ſpecies; and ſince no bodily difference is found in the human race, as will preſently appear, either in regard to ſtature, colour, the form of the cranium, &c. which is not obſerved in the ſame proportion among the ſwine race, while no one, on that account, ever doubts that all theſe different kinds are merely varieties that have ariſen from degeneration through the influence of climate, &c. this compariſon, it is to be hoped, will ſilence thoſe ſceptics who have thought proper, on account of theſe varieties in the human race, to admit more than one ſpecies.

“ With regard to ſtature, the Patagonians, as is well known, have afforded the greateſt employment to anthropologiſts. The romantic tales, however, of the old travellers, who give to theſe inhabitants of the ſouthern extremity of America a ſtature of ten feet and more, are ſcarcely worth notice; and even the more modeſt relations of later Engliſh navigators, who make their height from ſix to ſeven feet, have been doubted by other travellers, who, on the ſame coaſt, ſought for ſuch children of Enoch in vain. But we ſhall admit every thing ſaid of the extraordinary ſize of theſe Patagonians by Byron, Wallis, and Carteret; the firſt of whom aſſigns to their chief, and ſeveral of his attendants, a height of not leſs than ſeven feet, as far as could be determined by the eye; the ſecond, who aſſerts that he actually meaſured them, gives to the greater part of them from 5 feet 10 inches to 6 feet; to ſome 6 feet 5 inches, and 6 feet 6; but to the talleſt, 6 feet 7 inches: and this account is confirmed by the laſt-mentioned of the above circumnavigators. Now, allowing this to be the caſe, it is not near ſuch an exceſs of ſtature as that obſerved in many parts of America among the ſwine, originally carried thither from Europe; and of theſe I ſhall mention in particular thoſe of Cuba, which are more than double the ſize of the original ſtock in Europe.

“ The natives of Guinea, Madagaſcar, New Holland, New Guinea, &c. are black; many American tribes are reddiſh brown, and the Europeans are white. An equal difference is obſerved among ſwine in different countries. In Piedmont, for example, they are black. When I paſſed (ſays our author) through that country, during the great fair for ſwine at Salenge, I did not ſee a ſingle one of any other colour. In Bavaria, they are reddiſh brown; in Normandy, they are all white.

“ Human hair is, indeed, ſomewhat different from ſwine's briſtles; yet, in the preſent point of view, they may be compared with each other. Fair hair is ſoft, and of a ſilky texture; black hair is coarſer, and among ſeveral tribes, ſuch as the Abyſſinians, Negroes, and the inhabitants of New Holland, it is woolly, and moſt ſo among the Hottentots. In the like manner, among the white ſwine in Normandy, as I was aſſured by an incomparable obſerver, Sulzer of Ronneburg, the hair on the whole body is longer and ſofter than among other ſwine; and even the briſtles on the back are very little different, but lie flat, and are only longer than the hair on the other parts of the body. They cannot, therefore, be employed by the bruſh-makers. The difference between the hair of the wild boar and the domeſtic ſwine, particularly in regard to the ſofter part between the ſtrong briſtles, is, as is well known, ſtill greater.

“ The whole difference between the cranium of a Negro and that of an European, is not in the leaſt degree greater than that equally ſtriking difference which exiſts between the cranium of the wild boar and that of the domeſtic ſwine. Thoſe who have not obſerved this in the animals themſelves, need only to caſt their eye on the figure which Daubenton has given of both.

“ I ſhall paſs over (ſays our author) leſs national varieties which may be found among ſwine as well as among men, and only mention, that I have been aſſured by Mr Sulzer, that the peculiarity of having the bone of the leg remarkably long, as is the caſe among the Hindoos, has been remarked with regard to the ſwine in Normandy. ‘ They ſtand very long on their hind legs (ſays he, in one of his letters); their back, therefore, is higheſt at the rump, forming a kind of inclined plane; and the head proceeds in the ſame direction, ſo that the ſnout is not far from the ground.’ I ſhall here add, that the ſwine, in ſome countries, have degenerated into races which in ſingularity far exceed every thing that has been found ſtrange in bodily variety among the human race. Swine with ſolid hoofs were known to the ancients, and large herds of them are found in Hungary, Sweden, &c. In the like manner, the European Swine, firſt carried by the Spaniards, in 1509, to the iſland of Cuba, at that time celebrated for its pearl fiſhery, degenerated into a monſtrous race, with hoofs which were half a ſpan in length.”

From theſe facts, our author concludes, that it is abſurd to allow the vaſt variety of ſwine to have deſcended from one original pair, and to contend that the varieties of men are ſo many diſtinct ſpecies.

MANDING, a large ſtate in the interior of Africa, of which the only ſatisfactory account that we have is by Mr Park, who, for ſeveral months, was hoſpitably entertained in Kamalia, one of its towns, ſituated in 12° 40′ N. Lat. and 6° 40′ W. Long. The government of Manding appeared to our author to be a ſort of republic, or rather an oligarchy. Every town is indeed governed by a chief magiſtrate called Manſa, which uſually ſignifies king; but the chief power of the ſtate, in the laſt reſort, is lodged in the aſſembly of theſe manſas (A). The caſe, however, is different in other countries, which are occupied by people who have emigrated from Manding; for in all the Mandingo ſtates near

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(A) Mr Park, for the moſt part, writes with remarkable perſpicuity; but we are not ſure that here we have not miſtaken his meaning. He ſays, that the chief power of the ſtate is lodged in the aſſembly of that *whole body*; but we think, that by the whole body muſt be meant the body of *Manſas*, otherwiſe the government could not be called an oligarchy.

near the Gambia, the government is monarchical, tho' the power of the ſovereign is by no means unlimited.

As Mr Park's route was confined to a tract of country, bounded nearly by the 12th and 15th parallels of latitude, the climate throughout the whole was nearly the ſame as that of Manding, and extremely hot: Yet, where the country aſcended into hills, he found it comparatively cool and pleaſant; though none of the diſtricts which he traverſed could be called mountainous. About the middle of June, the hot and ſultry atmoſphere is agitated by violent guſts of wind (called *tornadoes*), accompanied with thunder and rain. Theſe uſher in what is denominated *the rainy ſeaſon*; which continues until the month of November. During this time, the diurnal rains are very heavy; and the prevailing winds are from the ſouth-weſt. The termination of the rainy ſeaſon is likewiſe attended with violent tornadoes; after which the wind ſhifts to the north-eaſt, and continues to blow from that quarter during the reſt of the year.

When the wind ſets in from the north-eaſt, it produces a wonderful change in the face of the country. The graſs ſoon becomes dry and withered; the rivers ſubſide very rapidly, and many of the trees ſhed their leaves. About this period is commonly felt the *harmattan*, a dry and parching wind, blowing from the north eaſt, and accompanied by a thick ſmoky haze; through which the ſun appears of a dull red colour. This wind, in paſſing over the great deſert of Sahara, acquires a very ſtrong attraction for humidity, and parches up every thing expoſed to its current. It is, however, reckoned very ſalutary, particularly to Europeans, who generally recover their health during its continuance. The truth of this our author experienced both at Kamalia and Piſania, when he had been brought to the very brink of the grave by ſickneſs.

Whenever the graſs is ſufficiently dry, the negroes ſet it on fire; but in Ludamar, and other Mooriſh countries, this practice is not allowed; for it is upon the withered ſtubble that the Moors feed their cattle until the return of the rains. The burning of the graſs in Manding exhibits a ſcene of terrific grandeur. "In the middle of the night (ſays Mr Park), I could ſee the plains and mountains, as far as my eye could reach, variegated with lines of fire; and the light reflected on the ſky, made the heavens appear in a blaze. In the day time, pillars of ſmoke were ſeen in every direction; while the birds of prey were obſerved hovering round the conflagration, and pouncing down upon the ſnakes, lizards, and other reptiles, which attempted to eſcape from the flames." This annual burning is ſoon followed by a freſh and ſweet verdure, and the country is thereby rendered more healthful and pleaſant.

Though many ſpecies of the edible roots, which grow in the Weſt India iſlands, are found in Africa, yet our traveller never ſaw, in any part of his journey, either the ſugar cane, the coffee, or the cocoa tree; nor could he learn, on inquiry, that they were known to the natives. The pine-apple, and the thouſand other delicious fruits which the induſtry of civilized man (improving the bounties of nature), has brought to ſo great perfection in the tropical climates of America, are here equally unknown. He obſerved, indeed, a few orange and banana trees, near the mouth of the Gambia; but whether they were indigenous, or were formerly planted there by ſome of the white traders, he could not poſitively learn.

Concerning property in the ſoil, it appeared to Mr Park, that the lands in native woods were conſidered as belonging to the king, or (where the government was not monarchical) to the ſtate. When any individual of free condition had the means of cultivating more land than he actually poſſeſſed, he applied to the chief man of the diſtrict, who allowed him an extenſion of territory, on condition of forfeiture if the lands were not brought into cultivation by a given period. The condition being fulfilled, the ſoil became veſted in the poſſeſſor; and, for aught that appeared, deſcended to his heirs.

The Mandingoes are a very gentle race of people; cheerful in their diſpoſitions, inquiſitive, credulous, ſimple, and fond of flattery. The men are commonly above the middle ſize, well ſhaped, ſtrong, and capable of enduring great labour; the women are good natured, ſprightly, and agreeable. The dreſs of both ſexes is compoſed of cotton cloth of their own manufacture; that of the men is a looſe frock, not unlike a ſurplice, with drawers which reach half way down the leg; and they wear ſandals on their feet, and white cotton caps on their heads. The womens dreſs conſiſts of two pieces of cloth, each of which is about ſix feet long and three broad; one of theſe they wrap round the waiſt, which, hanging down to the ancles, anſwers the purpoſe of a petticoat; the other is thrown negligently over the boſom and ſhoulders. Both men and women among the Mandingoes ſeem to have an invincible propenſity to commit depredations on the property of unprotected ſtrangers; whilſt ſuch is the good nature of thoſe poor heathens, that they will readily ſympathiſe in the ſufferings, relieve the diſtreſſes, and contribute to the perſonal ſafety, of the very ſtrangers whom they are bent upon plundering.

Among the Mandingoes, the parental and filial affection is remarkably ſtrong between the mother and her child; but not ſo between the father and his children. This, as Mr Park obſerves, is eaſily accounted for. The ſyſtem of polygamy, while it weakens the father's attachment, by dividing it among the children of different wives, concentrates all the mother's jealous tenderneſs to one point, the protection of her own offspring. He perceived, with great ſatisfaction too, that the maternal ſolicitude extended, not only to the growth and ſecurity of the perſon, but alſo, in a certain degree, to the improvement of the mind of the infant; for one of the firſt leſſons, in which the Mandingo women inſtruct their children, is *the practice of truth*.

The Mandingo women ſuckle their children until they are able to walk of themſelves. Three years nurſing is not uncommon; and during this period, the huſband devotes his whole attention to his other wives. To this practice it is owing, that the family of each wife is ſeldom very numerous. Few women have more than five or ſix children. As ſoon as an infant is able to walk, it is permitted to run about with great freedom. The mother is not over ſolicitous to preſerve it from ſlight falls, and other trifling accidents. A little practice ſoon enables a child to take care of itſelf, and experience acts the part of a nurſe. As they advance in life, the girls are taught to ſpin cotton, and to beat corn, and are inſtructed in other domeſtic duties; and the boys are employed in the labours of the field. Both ſexes, whether Buſhreens or Kafirs, on attaining the age of puberty, are circumciſed. This painful operation is not conſidered by the Kafirs ſo much in the light of a religious ceremony, as a matter of convenience and utility. They have, indeed, a ſuperſtitious notion, that it contributes to render the marriage ſtate prolific.

When a young man takes a fancy to a young girl, and wiſhes to marry her, it is by no means conſidered as neceſſary that he ſhould make an overture to the girl herſelf. The firſt object is to agree with the parents, concerning the recompence to be given them for the loſs of the company and ſervices of their daughter. The value of two ſlaves is a common price, unleſs the girl is thought very handſome; in which caſe, the parents will raiſe their demand very conſiderably. If the lover is rich enough, and willing to give the ſum demanded, he then communicates his wiſhes to the damſel: but her conſent is by no means neceſſary to the match; for if the parents agree to it, and eat a few *kolla-nuts*, which are preſented by the ſuitor as an earneſt of the bargain, the young lady muſt either have the man of their choice, or continue unmarried, for ſhe cannot afterwards be given to another. If the parents ſhould attempt it, the lover is then authoriſed, by the laws of the country, to ſeize upon the girl as his ſlave. At the celebration of a marriage, no religious ceremony ſeems to be practiſed. A ſelect number of people are indeed invited to the wedding, and feaſted; but conſummation conſtitutes the marriage; for towards the morning, the new married couple are always diſturbed by the women, who aſſemble to inſpect the nuptial ſheet (according to the manners of the ancient Hebrews, as recorded in Scripture), and dance round it. This ceremony is thought indiſpenſably neceſſary; nor is the marriage conſidered as valid without it.

The Mandingoes, and indeed all the negro ſtates, whether Mahomedan or Pagan, allow a plurality of wives. The conſequence is, that the wives frequently quarrel among themſelves. When this happens, the huſband decides between them; and ſometimes finds it neceſſary to adminiſter a little corporal chaſtiſement before tranquillity can be reſtored. But if any one of the ladies complains to the chief of the town, that her huſband has unjuſtly puniſhed her, and ſhewn an undue partiality to ſome other of his wives, the affair is brought to a public trial. In theſe *palavers*, however, which are conducted chiefly by married men, our author was informed, that the complaint of the wife is not always conſidered in a very ſerious light; and the complainant herſelf is ſometimes convicted of ſtrife and contention, and left without remedy. If ſhe murmurs at the deciſion of the court, the magic rod of *Mumbo Jumbo* ſoon puts an end to the buſineſs. See Mumbo Jumbo in this *Suppl.*

A child, among them, is named when it is ſeven or eight days old. The ceremony commences by ſhaving the infant's head; and a diſh called *dega*, made of pounded corn and ſour milk, is prepared for the gueſts. If the parents are rich, a ſheep or a goat is commonly added. This feaſt is called *ding koon lee*, "the child's head ſhaving." During Mr Park's ſtay at Kamalia, he was preſent at four different feaſts of this kind, and the ceremony was the ſame in each, whether the child belonged to a Buſhreen or a Kafir. The ſchoolmaſter, who officiated as prieſt on thoſe occaſions, and who is neceſſarily a Buſhreen, firſt ſaid a long prayer over the *dega*; during which, every perſon preſent took hold of the brim of the calabaſh with his right hand. After this, the ſchoolmaſter took the child in his arms, and ſaid a ſecond prayer; in which he repeatedly ſolicited the bleſſing of God upon the child, and upon all the company. When this prayer was ended, he whiſpered a few ſentences in the child's ear, and ſpit three times in its face; after which he pronounced its name aloud, and returned the infant to the mother. This part of the ceremony being ended, the father of the child divided the *dega* into a number of balls, one of which he diſtributed to every perſon preſent. And inquiry was then made, if any perſon in the town was dangerouſly ſick; it being uſual, in ſuch caſes, to ſend the party a large portion of the *dega*, which is thought to poſſeſs great medical virtues.

The Mandingoes have no artificial method of dividing time. They calculate the years by the number of *rainy ſeaſons*. They portion the year into *moons*, and reckon the days by ſo many *ſuns*. The day they divide into morning, mid day, and evening; and further ſubdivide it, when neceſſary, by pointing to the ſun's place in the heavens. Our author frequently inquired of ſome of them, what became of the ſun during the night, and whether we ſhould ſee the ſame ſun, or a different one, in the morning? But that ſubject appeared to them as placed beyond the reach of human inveſtigation; they had never indulged a conjecture, nor formed any hypotheſis, about the matter. The moon, by varying her form, has more attracted their attention. On the firſt appearance of the new moon, which they look upon to be newly created, the Pagan natives, as well as Mahomedans, ſay a ſhort prayer; and this ſeems to be the only viſible adoration which the Kafirs offer up to the Supreme Being. This prayer is pronounced in a whiſper; the party holding up his hands before his face: its purport is to return thanks to God for his kindneſs through the exiſtence of the paſt moon, and to ſolicit a continuation of his favour during that of the new one. At the concluſion, they ſpit upon their hands, and rub them over their faces. Great attention is paid to the changes of this luminary in its monthly courſe; and it is thought very unlucky to begin a journey, or any other work of conſequence, in the laſt quarter. An eclipſe, whether of the ſun or moon, is ſuppoſed to be effected by witchcraft. The ſtars are very little regarded; and the whole ſtudy of aſtronomy appears to them as a uſeleſs purſuit, and attended to by ſuch perſons only as deal in magic.

Their notions of geography are equally puerile. They imagine that the world is an extended plain, the termination of which no eye has diſcovered; it being, they ſay, overhung with clouds and darkneſs. They deſcribe the ſea as a large river of ſalt water, on the farther ſhore of which is ſituated a country called *Tobaubo doo*; "the land of the white people." At a diſtance from Tobaubo doo, they deſcribe another country, which they allege is inhabited by cannibals of gigantic ſize, called *Kcomi*.

Mr Park ſays he has converſed with all ranks and conditions of negroes on the ſubject of their faith, and that he can pronounce, without the ſmalleſt ſhadow of doubt, that the belief of one God, and of a future ſtate of reward and puniſhment, is entire and univerſal among them. It is remarkable, however, that, except on the appearance of a new moon, as before related, the Pagan natives do not think it neceſſary to offer up prayers and ſupplications to the Almighty. They repreſent the Deity, indeed, as the creator and preſerver of all things; but in general they conſider him as a Being ſo remote, and of ſo exalted a nature, that it is idle to imagine the feeble ſupplications of wretched mortals can reverſe the decrees, and change the purpoſes, of unerring wiſdom. The concerns of this world, they believe, are committed by the Almighty to the ſuperintendance and direction of ſubordinate ſpirits, over whom they ſuppoſe that certain magical ceremonies have great influence. A white fowl, ſuſpended to the branch of a particular tree, a ſnake's head, or a few handfuls of fruit, are offerings which ignorance and ſuperſtition frequently preſent, to deprecate the wrath, or to conciliate the favour, of theſe tutelary agents.

The Mandingoes ſeldom attain extreme old age. At forty, moſt of them become grey haired, and covered with wrinkles; and but few of them ſurvive the age of fifty-five, or ſixty. Yet their diſeaſes appeared but few; fevers and fluxes being the moſt common, and the moſt fatal. For theſe they generally apply *ſaphies*, i. e. charms, to different parts of the body; though ſometimes, on the firſt attack of a fever, the patient is, with great ſucceſs, placed in a ſort of vapour bath. The other diſeaſes which prevail among the negroes, are the *yaws*, the *elephantiaſis*, and a *leproſy* of the very worſt kind, together with the *Guinea worm*, which they attribute to bad water.

When a perſon of conſequence dies, the relations and neighbours meet together, and manifeſt their ſorrow by loud and diſmal howlings. A bullock or goat is killed for ſuch perſons as come to aſſiſt at the funeral; which generally takes place in the evening of the ſame day on which the party died. The negroes have no appropriate burial places, and frequently dig the grave in the floor of the deceaſed's hut, or in the ſhade of a favourite tree. The body is dreſſed in white cotton, and wrapped up in a mat. It is carried to the grave, in the duſk of the evening, by the relations. If the grave is without the walls of the town, a number of prickly buſhes are laid upon it, to prevent the wolves from digging up the body; but our author never obſerved that any ſtone was placed over the grave as a monument or memorial.

With reſpect to employment, the men cultivate the ground, or catch fiſh in large rivers; while the women manufacture cotton cloth. It is only the ſpinning and the dyeing, however, that are performed by the women; for the web, which is ſeldom more than four inches broad, is wove by the men in a loom made exactly upon the ſame principle as that of Europe. As the arts of weaving, dyeing, ſewing, &c. may eaſily be acquired, thoſe who exerciſe them are not conſidered in Africa as following any particular profeſſion; for almoſt every ſlave can weave, and every boy can ſew. The only artiſts which are diſtinctly acknowledged as ſuch by the negroes, and who value themſelves on exerciſing appropriate and peculiar trades, are the manufacturers of leather and of iron. The firſt of theſe are called *Karrankea* (or as the word is ſometimes pronounced *Gaungay*). They are to be found in almoſt every town, and they frequently travel through the country in the exerciſe of their calling. They tan and dreſs leather with very great expedition, by ſteeping the hide firſt in a mixture of wood-aſhes and water, until it parts with the hair; and afterwards by uſing the pounded leaves of a tree, called *goo*, as an aſtringent.

The manufacturers in iron are not ſo numerous as the *Karrankeas;* but they appear to have ſtudied their buſineſs with equal diligence. The negroes on the coaſt being cheaply ſupplied with iron from the European traders, never attempt the manufacturing of this article themſelves; but in the inland parts, the natives ſmelt this uſeful metal in ſuch quantities, as not only to ſupply themſelves from it with all neceſſary weapons and inſtruments, but even to make it an article of commerce with ſome of the neighbouring ſtates. During our author's ſtay at Kamalia, there was a ſmelting furnace at a ſhort diſtance from the hut where he lodged, and the owner and his workmen made no ſecret about the manner of conducting the operation; and readily allowed him to examine the furnace, and aſſiſt them in breaking the iron-ſtone. The proceſs it is needleſs to deſcribe; though it be proper to obſerve, that the maſs of metal obtained by it was rather ſteel than iron. Moſt of the African blackſmiths are acquainted alſo with the method of ſmelting gold, in which proceſs they uſe an alkaline ſalt, obtained from a ley of burnt corn-ſtalks evaporated to dryneſs. They likewiſe draw the gold into wire, and form it into a variety of ornaments, ſome of which are executed with a great deal of taſte and ingenuity.

The reader will obſerve, that in the extracts which we have made from Mr Park's intereſting travels, the terms African and Negro are frequently uſed as if all Africans and Negroes were Mandingoes. The reaſon is, that the Mandingoes were not only the moſt numerous tribe which he viſited, but were alſo ſpread over all that tract of country which he traverſed.

MANIANA, a ſmall negro kingdom lying between 12° and 14° North Lat. and between the meridian of Greenwich and 1° and 30′ Weſt Long. Its inhabitants, as Mr Park was informed by a variety of people in many different kingdoms, are remarkable for cruelty and ferocity; carrying their reſentment to their enemies ſo far as never to give quarter, and even indulging themſelves with banquets of human fleſh. Hence the inhabitants of Bambarra, who carried on with them a long and bloody war, and muſt of courſe be well aſcertained of the fact, call them *Ma dummulo*, which ſignifies meneaters.

MANURE is ſo eſſential to agriculture, that the want of it, or an improper manner of uſing it, is the principal cauſe of the ſterility of a country. We have therefore treated of manures and their action at ſome length in the article AGRICULTURE in the *Encyclopædia;* but as the theoretical part of that diſquiſition reſts in a great meaſure on the doctrine of phlogiſton, which is now exploded, it may not be improper to reſume the ſubject here. Experience however being, after all, the only guide which the farmer can ſafely and confidently follow, inſtead of amuſing our readers with theories of our own, we ſhall lay before them the obſervations of a man who ſeems to have united theory with practice.

"The uſe of manures (ſays M. Parmentier *) has been known in all ages, but we are yet far from having any clear and preciſe ideas of the nature of the juices which are deſtined for the nouriſhment of vegetables, and of the manner in which they are tranſmitted to their organs. The writers on agriculture, who have endeavoured to explain theſe matters, perceiving ſalts in moſt plants, were perſuaded that theſe ſalts, by the help of water and heat, paſſed, in a ſaline form, through the vegetable filter. Theſe firſt philoſophers did not heſitate to conſider every thing that has been done by the induſtry of man, to improve the nature of land, and its productions, as merely forming reſervoirs of theſe ſalts, which they conſidered as the principle of fertility. This opinion was ſo well eſtabliſhed among the improvers of land, that, to this day, many of them have no object in view, in their operations, but to diſengage ſalts; and, when they attempt to explain certain phenomena which take place in their fields or orchards, they talk confidently about the *nitre of the air*, *of rain*, *of ſnow*, *of dew*, *and fogs*; of the *ſalts of the earth*, *of dung*, *of marle*, *of lime*, *of chalk*, &c. and make uſe of thoſe vague terms, *oil*, *ſulphur*, *ſpirit*, &c. which ought henceforward to be baniſhed from our elementary books on agriculture.

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* *Memoirs of the Royal Society of Agriculture, Paris.*

“ Among the authors who have attacked, and combated with moſt ſucceſs, the opinion that the fruitfulneſs of ſoils, and the aliment of vegetables, reſide in ſaline ſubſtances, muſt be reckoned Eller and Wallerius. Theſe philoſophers examined, by every means which chymiſtry at that time could furniſh, the various kinds of earth proper for cultivation, and alſo thoſe ſubſtances which have always been conſidered as the moſt powerful manures, without being able to obtain, from any of them, any thing more than mere atoms of ſalt.

“ Animated with the ſame zeal, and taking advantage of the inſtructions found in their writings, I thought it neceſſary to determine, by experience, whether, as has been aſſerted, there really exiſt neutral ſalts in earths; and alſo, whether thoſe earths are more fertile in proportion to the quantity of ſuch ſalts they contain. With this view, I lixiviated, by means of diſtilled water, many ſpecies of cultivated earths, taken in various ſtates, from freſh earth to that which had been impoveriſhed by the growth of ſeveral crops; I alſo tried dung, reduced more or leſs into the ſtate of mould; and likewiſe the moſt active manures, ſuch as the offal of animal ſubſtances rotted by putrefaction; but in none of theſe, however carefully analyzed, were found any ſalts in a free ſtate. They contain indeed the materials proper for forming ſalts, but if they contain any ready formed, it is merely by accident.

“ The reſearches of Kraft, and thoſe of Alſton, were not attended with different reſults. Having ſown ſome oats in aſhes, not lixiviated, and in ſand ſtrongly impregnated with potaſh and with ſaltpetre, and having found that the oats did not grow, they concluded that neutral ſalts, and alkalies, not only retarded the growth of vegetables, but that they abſolutely prevented it. It is well known that in Egypt there are diſtricts where the earth is entirely covered with ſea-ſalt, and theſe diſtricts are quite barren. It is probably owing to this property of ſea-ſalt, that the Romans were accuſtomed to ſcatter large quantities of it over fields where any great crime had been committed, and of which they wiſhed to perpetuate the remembrance, by rendering the part barren for a certain time.

“ The idea that ſalts had great influence in vegetation, ought to have been greatly weakened by the following ſimple reflection. Suppoſing that ſalts exiſted in garden mould, they would be very ſoon diſſolved by the rain, and carried away, towards the lower ſtrata of the earth, to a depth to which the longeſt roots would not reach. Indeed the famous experiment of Vanhelmont would have been ſufficient to have deſtroyed the above opinion, if it did not generally happen that we are no ſooner ſet free from one error than we fall into another not leſs extraordinary. The ſurpriſing effects of vegetation brought about by the overflowing of water, and in the neighbourhood of ſalt marſhes, and the infinite number of inhaling capillary tubes obſerved upon the ſurface of vegetables, led to an opinion that the air and water, abſorbed by the roots and leaves of plants, were only vehicles loaded with ſaline matter, analogous to the vegetables nouriſhed by them.

“ To the experiment of Vanhelmont, which was repeated by many accurate obſervers, ſucceeded thoſe of modern philoſophers; from which it clearly appeared, that plants could grow, and produce fruit, in the air of the atmoſphere, and in diſtilled water, alſo in pure ſand, in powdered glaſs, in wet moſs or ſponge, in the cavity of fleſhy roots, &c. and that plants which had nothing but the above-mentioned fluids for their nouriſhment, gave, when ſubmitted to chymical analyſis, the ſame products as thoſe which had undergone their proceſs of vegetation in a ſoil perfectly well manured. It was alſo obſerved, that the moſt barren ſoils were rendered fertile when they were properly ſupplied with water by canals; and the efficacy of irrigation was repeatedly evinced in different ways: from theſe obſervations was formed the following ſyſtem, that water riſes in plants in the form of vapour, as in diſtillation; that air introduces itſelf into their pores; and that, if ſalts contribute to the fruitfulneſs of ſoils, it is only in conſequence of their containing the two fluids above-mentioned in great abundance.”

Our author, after making many experiments upon various ſoils and ſalts, and after attending minutely to the proceſs of vegetation, thinks himſelf warranted to maintain, “ that ſaline ſubſtances have no ſenſible effects in promoting vegetation, except inaſmuch as they are of a deliqueſcent nature, have an earthy baſis eaſily decompoſed, and are uſed only in ſmall quantity. In thoſe circumſtances they have the power of attracting, from the immenſe reſervoir of the atmoſphere, the vapours which circulate in it; theſe vapours they retain, along with the moiſture that is produced from rain, ſnow, dew, fog, &c. which moiſture they prevent from running together in a maſs, or from being loſt, either by exhaling into the air of the atmoſphere, or by filtering itſelf through the inferior ſtrata of the earth, and thereby leaving the roots of vegetables dry; they diſtribute that moiſture uniformly, and tranſmit it, in a ſtate of great diviſion, to the orifices of the tubes deſtined to carry it into the texture of the plant, where it is afterwards to undergo the laws of aſſimilation. As every kind of vegetable manure poſſeſſes a viſcous kind of moiſture, it thereby partakes of the property of deliqueſcent ſalts. In ſhort, the preparation of land for vegetation has no other object in view but to divide the earthy particles, to ſoften them, and to give them a form capable of producing the above mentioned effects. It is ſufficient, therefore, that water, by its mixture with the earth and the manure, be divided, and ſpread out ſo as to be applied only by its ſurface, and that it keep the root of the plant always wet, without drowning it, in order to become the eſſential principle of vegetation. But as plants which grow in the ſhade, even in the beſt ſoil, are weakly, and as the greater part of thoſe which are made to grow in a place that is perfectly dark neither give fruit nor flowers, it cannot be denied that the influence of the ſun is of great importance in vegetable economy."

Such was the opinion which our author gave of the manner in which ſalts act in vegetation, at a time when it was not known that air and water (which had been ſo long conſidered as elements), far from being ſimple ſubſtances, are capable of being decompoſed by a great variety of operations both of nature and art; and nothing was wanting to complete his theory, but to know that air and water act their part in vegetation only in a ſtate of decompoſition; and that if earth well manured is a better matrix than water itſelf, it is becauſe ſuch earth has the power of converting the water into gaſes which are eaſily abſorbed, and which, while their abſorption takes place, communicate to the plants a motion and heat which they received when taking the form of gas, and which they loſe when they enter again into combination; whence it is natural to conclude, that this motion and this heat muſt neceſſarily develope themſelves in ſeeds, and maintain the vital action in plants.

What is a vegetable, conſidered chemically, according to the preſent ſtate of our knowledge? It is, ſay the chemiſts, a compound of hydrogen, oxygen, and carbon, the proportions of which vary according to the agents which have concurred to its developement, and according to the matrix which received and aſſimilated them, in order to create thoſe combinations which are varied to infinity, by their forms and properties, and known by the generic terms of ſalt, oil, and mucilage. It appears, therefore, needleſs to ſeek theſe combinations in the different ſubſtances which are uſed for manure, when we wiſh to determine the nature of them, and explain their manner of acting in vegetation; becauſe, ſuppoſing it true that theſe ſalts, theſe oils, or theſe mucilages, exiſt in their combined ſtate, nothing but their conſtituent elements, namely, hydrogen, oxygen, and carbon, can poſſibly have any action.

The ſuperiority of animal ſubſtances, as manures, and the remarkable luxuriance of thoſe plants which are watered with putrid water, prove inconteſtibly, that the putrid ſtate is favourable to vegetation, and that every ſubſtance which is liable to enter, to a certain degree, into that ſtate, contributes very powerfully thereto. The moſt aerated waters are, in this caſe, the moſt beneficial. It is obſerved that rain, particularly in ſtormy weather, quickens vegetation ſo much, that the gardeners in the neighbourhood of Paris are often obiged to drench their plants with water taken from their wells, which, in conſequence of its rawneſs, or its want of air, retards the vegetation of the plants; either becauſe it precipitates the meteoriſed or electrified water, or becauſe, by being mixed with the other water, it diminiſhes its fertilizing quality; whereas, in ſummer, this ſame well-water, by being expoſed to the ſun for ſome days, acquires a ſmell like that of ſtale eggs, loſes its rawneſs, and becomes very fit for accelerating vegetation. An atom of vegetable or animal matter is, at that time, ſufficient to bring about more quickly this ſtate of putrefaction; while theſe ſame ſubſtances, by being employed in certain proportions, far from acting as a leaven on the liquids which hold them in ſolution, preſerve thoſe liquids, or at leaſt make them more ſlow to change.

Salts and dung, therefore, are not merely decompoſed by the power of vegetation; by furniſhing the reſults of their decompoſition, they alſo act in the manner of leavens, the action of which is ſcarcely perceptible in cold or dry weather; but when they are heated by the ſun, and ſufficiently penetrated with moiſture, they very ſoon enter into a ſort of fermentation, ſuffering the various gaſes with which they are provided to eſcape. Thus manures may be conſidered as decompoſing inſtruments, provided by nature, and prepared by art, to act upon water ſo as to bring it to a proper ſtate of attenuation. The ſubſtances which enter into the compoſition of plants are, therefore, nothing but products of the decompoſition of air and water, and combinations of the conſtituent principles of theſe two fluids, determined by the power which preſides in the ſeed, and which thence has paſſed into the plant.

It is now eaſy to account for the effects of charcoal-powder, ſtraw, &c. which are made uſe of to cover ground during long droughts with undoubted benefit: they are mechanical means of preventing the diſſipation of moiſture, and of determining it to take the form of thoſe gaſeous fluids which have ſuch powerful effect in vegetation. As water is compoſed of hydrogen and oxygen, it is not ſurpriſing that, when aſſiſted by the influence of the ſun, and that of electricity, it is capable of forming, almoſt by itſelf, the ſolids and fluids of vegetables; taking from the atmoſphere the carbon it ſtands in need of, to give them their moſt eſſential characters. We ſay their moſt eſſential characters; for thoſe terreſtrial plants which have grown in air and water do not abound in principles, and their offspring, when they have any, is by no means vigorous. We ſee alſo, that plants which are naturally of an aquatic nature, have in general but little ſmell, becauſe the medium in which they live and grow furniſhes only a ſmall quantity of carbon, in proportion to the hydrogen and oxygen, which are the conſtituent principles of water. This is the reaſon why, in cold and wet years, flowers are leſs odoriferous, fruit leſs full of flavour, and more difficult to be preſerved. The germ of their reproduction is weak; and they are, if the expreſſion may be uſed, in a ſort of dropſy; that is to ſay, they are loaded with the principles which conſtitute water, and even with water itſelf.

Theſe obſervations, to which more might be added, may ſerve to explain why vegetation is ſlow and weak in a ſoil which is too much charged with ſaline matter, while it is rendered quick and vigorous by a ſmall quantity of this ſame matter; and why earth, which is perfectly lixiviated, and watered, from time to time, with diſtilled water only, is capable of giving to bitter plants their bitterneſs, to ſweet ones their ſweetneſs, to acid ones their acidity, to aromatic ones their ſpicineſs, and to poiſonous ones their deleterious qualities; in ſhort, why the inherent characters of plants are more ſtrongly marked, in proportion as the ſoil in which they grow is furniſhed with natural or mechanical means to produce a quantity of gas neceſſary to the formation of the ſubſtances on which thoſe characters depend.

If a nitrous or marine plant can, even when growing in a ſoil deſtitute of nitre or ſea-ſalt, occaſion the production of theſe ſalts, it muſt be allowed that ſuch plants would vegetate more ſtrongly, and contain more of ſuch ſalts, if they grew in ſoils more abounding in materials proper to form them. Thus, the different ſpecies of ſamphire, glaſſwort, ſea-wrack, &c. flouriſh on the borders of the ſea, ſuch ſoils being ſtrongly impregnated with the fluids neceſſary to form the muriatic gas and ſea ſalt which enter into the compoſition of thoſe plants; while the ſun flower, pellitory, &c. ſucceed beſt in earth which is mixed with the ruins of old buildings, in which the materials for the production of nitrous gas, and even of nitre itſelf, are very abundant. In ſhort, the organization of theſe plants is a real elaboratory for forming the forementioned ſalts.

Thoſe plants which, for their vegetation, require the moſt aſſiſtance from the ſoil and manure, are very apt to contract a diſagreeable taſte, if either the ſoil or manure are capable of ſupplying the principles from which it is acquired. The claſs *tetradynamia*, particularly all ſorts of cabbages (which contain ſulphur ready formed), contract a bad taſte in a ſoil compoſed of mud and dung, becauſe theſe ſubſtances, as they are decompoſed, furniſh a great quantity of hepatic gas, or of ſulphuriſed hydrogen gas; yet plants of another claſs may grow in the ſame ſoil, cloſe by the cabbages, without partaking even in the ſmalleſt degree of the bad taſte of the latter. The plants laſt mentioned, when growing in hepatic gas, retain only ſo much of it as is ſufficient for the production of the ſubſtances of which they are formed; the overplus, which could not be aſſimilated, is thrown out by the excretory veſſels, after undergoing thoſe modifications which the digeſtive juices and organization of the plant, and the ſtate of the atmoſphere, have produced.

Thus we ſee that thoſe plants which abound moſt in oily, ſaline, and mucilaginous principles, are generally ſuch as require a ſoil well manured. Tobacco, for inſtance, gives forty pounds of alkaline ſalt or potaſh from every hundred weight of aſhes: this plant may, by being buried in the ground, be converted into a very powerful manure; while other plants, which thrive in a middling ſoil, and appear as vigorous, are, in general, ſuch as have not ſo great a quantity of principles in their compoſition, and when thrown on the dunghill, and left to rot, furniſh very little manure. From ſuch obſervations, it may perhaps not be impoſſible hereafter to judge, by the analyſis of a plant, not only whether it requires a large or a ſmall quantity of manure, but likewiſe what kinds of ſoil and manure are moſt fit to promote its vegetation: wild plants alſo may ſerve to ſhew the nature of the ſoil which they ſeem moſt to flouriſh in.

Beſides the phyſical action of manures, they have a very evident mechanical action. When mixed with earth, in a certain proportion, they not only render it more permeable to water, but the roots of plants can, with greater eaſe, acquire their proper ſize and form in it: in other caſes, manures tend to unite that earth which is too looſe, and, by rendering it more tenacious, they prevent the water from being loſt, and the roots from becoming dry. Thoſe manures which are called *warm* are ſuited to cold lands, not only becauſe they render them leſs compact, but alſo becauſe they take off a part of that moiſture which ſuch lands always have in too great quantity. Cold manures, on the other hand, by their viſcid quality, give tenacity to dry and hot ſoils, attracting and retaining, for a longer time, the moiſture which comes in their way. The nature of the ſoil muſt therefore determine what kind of manure it ſtands in need of, and alſo whether cultivating it by means of oxen or by horſes is preferable; for the manures produced from theſe two animals have thoſe oppoſite qualities which we have above deſcribed. By ſuch obſervations, we ſhall perhaps be able to reſolve a queſtion, reſpecting which the ſentiments of cultivators in many parts of the kingdom are much divided.

It cannot, however, be denied, that the earth is able of itſelf to ſerve as a baſis and ſupport to plants, and that it has an action more or leſs evident upon air, upon water, and upon dung. There is a well-known method of diſtinguiſhing clay from other earths; by merely breathing upon it, a ſmell is immediately perceived, ſufficiently ſtrong to ſhew that a decompoſition and freſh combination have taken place. In ſummer, after a drought of ſome days continuance, there always ariſes in the fields a particular ſmell during a ſhower of rain; and there is no kind of vegetable manure which, when mixed with earth, does not ſend forth a ſmell. This proves, that the nature of the ſoil muſt have an influence, not only upon air and upon water, but alſo upon the effect of manures; and that before we ſpeak of their power, we ſhould always ſpecify what kind of earth they were applied to; becauſe when manures and earth are mixed together, there enſues an action and reaction more or leſs favourable to vegetation.

Having examined to what degree air and water enter, in ſubſtance, into the veſſels of plants, and having ſhewn that the principal action of earth, of ſalts, and of manures, conſiſts in preparing, elaborating, and decompoſing theſe two fluids, and in giving to the products of their decompoſition the forms they require, to accompliſh the purpoſe of nature in vegetation, our author makes ſome obſervations upon the particular effects of certain ſubſtances uſed for improving land, ſuch as marl, lime, chalk, and wood aſhes; which are uſually applied either to an exhauſted ſoil, in order to reſtore it, or to a drooping plant, with a view to give it ſtrength. Of the efficacy of theſe ſubſtances no one doubts, but it does not appear that we are equally agreed reſpecting their manner of acting.

Marl (a manure whoſe effects are well known, and which is found to be of the greateſt benefit in thoſe diſtricts where it can be procured in ſufficient quantity) is capable of acting in the ſame manner as the moſt fertile ſoil, when the principles of which it is compoſed, namely, clay, ſand, calcareous earth, and magneſian earth, are juſtly proportioned to each other. But it is ſometimes compact and tenacious, becauſe it contains a ſuperabundant portion of clay, and at other times porous and friable, becauſe it contains too much ſand, and therefore is not in general fit for vegetation by itſelf. Theſe conſiderations ought always to be our guide when we mean to employ marl as a manure.

It has been ſuppoſed that *to marl* was a ſort of technical expreſſion, intended to denote the bringing together or dividing the earthy particles by means of clay or ſand. It appears to our author, that neither of the above operations can properly be called *marling;* becauſe, in either caſe, all we do is, to put the ſoil into a ſituation to receive and to profit by the influence of the atmoſphere, and that of the manures made uſe of. The peculiar principle of marl is, that part of it which, like lime, acts very powerfully upon the different aeriform fluids, is eaſily reduced to powder, efferveſces with acids, and ſends forth a quantity of air bubbles when water is poured upon it. Now this matter, which in a particular manner does the office of manure, reſides neither in clay nor in ſand. Upon the proportion of it depends the duration of the fertility it produces; conſequently it is of importance, when we make uſe of marl, to know which of its conſtituent parts it contains in the greateſt proportion, otherwiſe in ſome caſes we ſhould only add one common kind of earth to another. Hence our author infers, that for a chalky ſoil clay is the proper manure, and that in ſuch a ſoil a clay bottom is of more value than a gold mine.

" Wood-aſhes, as a manure, may be, in ſome reſpects, compared to marl; at leaſt they contain the ſame earths as thoſe which generally enter into the compoſition of marl, but they contain a greater quantity of ſaline ſubſtances, proceeding from the vegetables of which they are the reſidue, and from the proceſs made uſe of in their combuſtion; a proceſs which increaſes their activity, and ſhould render us careful in what manner and for what purpoſes we employ them. Wood aſhes, when ſcattered over fields, at proper times and in proper quantities, deſtroy weeds, and encourage the vegetation of good plants. But do the aſhes produce this effect by a ſort of corroſive power? I cannot (ſays our author) think it; for in that caſe all kinds of plants would indiſcriminately be acted upon by them, and to a certain degree deſtroyed.

" Beſides, the aſhes of freſh wood are ſeldom employed until they have been lixiviated, in which ſtate they are deprived of their cauſtic principle; thoſe aſhes which are moſt commonly made uſe of for manure are produced either from wood that has been floated in water, or from turf, or from pit-coal, and contain little or no alkaline ſalt.

" It appears much more probable that aſhes, when laid upon ground, deſtroy the weeds by a well-known effect, namely, by ſeizing with eagerneſs that moiſture which ſerved to produce thoſe weeds, and which in a ſuperabundant quantity is neceſſary to their exiſtence and ſupport. Whereas thoſe plants which have a firmer texture and a longer root, which are rendered ſtrong by age and by having withſtood the rigour of winter, and which are in fact the plants of which the fields are compoſed, do not ſuffer any damage from the application of the aſhes; but, on the contrary, by being freed from the ſuperfluous weeds which ſtifled them, and robbed them of a part of their ſuſtenance, they receive a quantity of nouriſhment proportioned to their wants. The ſtate of relaxation and languor to which they were reduced by a ſuperabundance of water, leaves them, the ſoil gets its proper conſiſtence, and the graſs, corn, &c. acquiring the ſtrength and vigour which is natural to them, ſoon overcome the moſs, ruſhes, and other weeds; thus a good crop, of whatever the field conſiſts of, is produced. It is in the above manner that wood aſhes act, whenever in the ſpring it is neceſſary to apply them to meadows, corn fields, &c. the plants of which are ſtifled and weakened by a luxuriant vegetation of weeds, the uſual conſequence of mild and wet winters.

" When wood aſhes produce an effect different from what is above deſcribed, it is either becauſe they happen to contain too much alkaline ſalt, or that they are laid on the ground in too great quantity, or that the fields to which they are applied were not ſufficiently wet to reſtrain their action; for when they are ſcattered upon cold ſoils, and buried by the plough before the time of ſowing, they are, like lime, of great ſervice. The laſt-mentioned ſubſtance is very efficacious in other circumſtances; and there is a well-known method of uſing it, practiſed by the Germans, as follows: A heap of lime is formed by the ſide of a heap of poor earth, and water is poured upon the lime; the earth is then thrown over it, and becomes impregnated with the vapours which eſcape from the lime while it is ſlaked. The earth, after being thus aerated, may be ſeparated; and although no lime remains mixed with it, is, by the operation juſt deſcribed, rendered capable of giving a luxuriant vegetation to whatever plants may be put into it.

" It is poſſible, therefore, to aerate earth as well as fluids; for this purpoſe, by mixing it with certain ſubſtances, during their decompoſition, we muſt attach to it the principles of which thoſe ſubſtances are compoſed; from which there reſults a matter ſo loaded with gas, as to form a more compound ſubſtance, and one which has acquired new properties. The Arabians, for example, who take great pains to improve their land, are accuſtomed to make large pits, which they fill with animals which happen to die: theſe pits they afterwards cover with calcareous or clayey earth; and after ſome time theſe earths, which of themſelves are ſterile, acquire the properties of the richeſt manures.

" The foregoing obſervations may at leaſt be conſidered as proving, that thoſe ſubſtances which, when employed freſh and in too great quantity, are moſt prejudicial to vegetation, have, on the contrary, an advantageous effect, when they are previouſly made to undergo a fermentation; or when they are mixed with earth or water, in a proportion adapted to the end propoſed. The graſs of fields in which cattle or poultry go to feed, after the firſt or ſecond crop of hay, appears to be dried by the urine and dung of thoſe animals; as if fire had been applied to it; whereas theſe ſame excrementitious ſubſtances, when combined with earth, or diluted with water, are capable, without any other preparation, of performing the office of good manure.

" But if animal ſecretions, when applied in ſubſtance to plants, were capable of acting upon them, as is affirmed, in ſuch a way as to corrode or burn them, how could ſeed which has been ſwallowed, and eſcaped the action of the digeſtive powers, be prolific when thrown out by the animal, after having remained ſo long in its dung? yet we often ſee oats, ſo circumſtanced, grow and produce ſeed. Is it not more conſiſtent with experience and obſervation to ſuppoſe, that theſe excrementitious ſubſtances, being ſtill endowed with animal heat, and with an organic motion, diffuſe round plants in vegetation a deleterious principle or inflammable gas, which deſtroys them; for ſoon after their application, the foliage of the plant grows yellow, dries up, and the plant withers, unleſs there happens a ſhower of rain which revives it. When theſe ſubſtances are diluted, by being mixed with water and earth, they loſe that principle which is ſo deſtructive to vegetable life, and an incipient fermentation augments their power as a manure, ſo that they may be immediately made uſe of without any apprehenſion of injury from their effects.

“ It appears, therefore, that any operation upon excrementitious ſubſtances, by which they are dried and reduced to powder, cannot be practiſed without depriving thoſe ſubſtances of a great part of ſuch of their principles as are eaſily evaporated, and upon which their fluidity depends; theſe principles, when diluted with water, and confined by being mixed with earth, are capable of increaſing the produce of the ſoil. Such is the way in which the huſbandmen in Flanders make uſe of this kind of manure, in the cultivation of a kind of rape or cole ſeed, which is to them a very important branch of agricultural induſtry and commerce; and they never obſerve that the ſap carries up any of thoſe principles which give ſuch manure its offenſive ſmell; nor do they obſerve, that the fodder produced from fields ſo manured, whether eaten freſh or dry, is diſagreeable to their cattle. The excrements of all animals would be injurious to plants, if applied too freſh, or in too great quantity; and a gardener could not commit a greater fault, than to put more than a certain quantity of them into the water he means to make uſe of to water his young plants; in ſhort, this kind of manure is to be uſed in a very ſparing manner; and he that is too prodigal of it will find, to his coſt, that exceſs, even of that which is otherwiſe beneficial, becomes an evil.

“ It muſt certainly be allowed, that excrementitious ſubſtances are a very advantageous manure for cold ſoils, and ſuited to moſt vegetable productions; a long experience of their effects over a large tract of country, and the acknowledged intelligence of the Flemiſh farmers, ought to be conſidered as ſufficient to overcome the prejudice that has been raiſed againſt this ſort of manure. Suppoſing that the bad effects which have been attributed to it, when uſed in the ſtate in which it is taken out of privies, &c. are not the offſpring of a prejudiced imagination, they may have ariſen from its having been made uſe of at an improper time, or in too great quantity; or from its having been applied to a ſoil and for the cultivation of plants to which it was not adapted; for we know that the exceſs of any kind of manure changes the ſmell and taſte of plants, and the ſame effect is produced by watering them too frequently. Striking examples of this change are ſeen in the ſtrawberry and in the violet, when ſuch as have grown in the woods are compared to thoſe produced from ſome of our over-manured gardens; alſo in the lettuce, and ſome other plants, when thoſe raiſed for ſale by the gardeners about Paris are compared to thoſe of ſome particular kitchen gardens. In the markets of ſome cities, the carrots, turnips, and potatoes of the fields, are preferred to the ſame kind of roots cultivated by the gardeners (A); for though the laſt are of a larger ſize, they have not ſo good a flavour. Some vegetables, therefore, are like certain wild ſpecies of the animal kingdom; they reſiſt every kind of culture, as thoſe animals reſiſt every effort to tame them.

“ Although experience has taught the Flemiſh farmers, that excrementitious ſubſtances are more active in their natural ſtate than when dried, yet it cannot be denied that drying them, and reducing them into powder, is ſometimes very advantageous, becauſe in that ſtate they are much leſs offenſive, are eaſily tranſported to any diſtance, and may be uſed when moſt convenient or moſt proper. In many cities the inhabitants pay to have their privies emptied: in other places, thoſe who empty them pay for their contents; and it would aſtoniſh any one to be told how great a revenue is produced in the city of Liſle in Flanders by the ſale of this kind of manure. I am, however (ſays our author), far from thinking that it is right, in all caſes, to employ it in the above mentioned ſtate of concentration; it would be better, in my opinion, to follow the example of the Flemiſh farmers, who uſe it the firſt year for the cultivation of plants for oil, or for hemp or flax; and the ſecond year for the beſt kinds of grain: thus obtaining two crops, inſtead of one, without any farther preparation of the land. What is ſaid above may be applied alſo to the manures produced from the dung of cattle, poultry, &c. (particularly to pigeons dung, the moſt powerful manure of its kind), all which, by being dried and powdered before they are uſed, loſe a great portion of their activity. From theſe obſervations another fact may be deduced, namely, that manure ſhould not be taken from the place where it has been thrown together until the ſeaſon of the year and the ſtate of the land are ſuch that it may be put into the ground as ſoon as it is brought to it. In ſome diſtricts a very injurious cuſtom prevails of carrying the manure into the fields, and leaving it there formed into ſmall heaps, expoſed for ſome days to the elements; during which time, either the ſun and wind dry up its natural moiſture, leaving a maſs which is much leſs active; or the rain diſſolves and carries away the extractive part impregnated with the ſalt. This kind of brine, which is the moſt powerful part of the manure, penetrates the earth to a conſiderable depth, and ſhews (by the thick tufts which ariſe in thoſe places, and which produce more ſtraw than grain) that manure ought to be put into the ground as ſoon as it is brought to it, becauſe it then poſſeſſes its full force and effect, and conſequently would be then uſed to the greateſt advantage.

“ We have always at hand the means of compoſing, from a great variety of vegetable and animal ſubſtances, ſuch manures as, when brought into a proper ſtate, and mixed with land, contribute to its fertility. Chemiſtry alſo offers to us a number of ſubſtances, which, although when uſed ſeparately they tend to diminiſh the fertiliſing quality of the earth, are yet capable, by being combined, of forming excellent manures; ſuch, for inſtance, is that ſaponaceous combination which is produced from a mixture of potaſh, oil, and earth. What an advantage it would be, if, inſtead of being ſparing of manure, the inhabitants of the country would endeavour to increaſe the number of theſe reſources, and to render them more beneficial, by employing them in a

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(A) We believe they are univerſally preferable.

Manure, Maouana.

more effectual manner. How many years had paſſed before it was known that the refuſe of apples and pears, after they are preſſed (and which uſed to be thrown away as uſeleſs), is capable of forming as valuable a manure, in cyder and perry countries, as the refuſe of grapes does in wine countries."

From what has been obſerved, our author concludes, that manures act, in many circumſtances, like medicines, and conſequently that the ſame ſort of manure cannot be adapted to every ſituation, and every kind of ſoil; we muſt therefore take care to make proper diſtinctions between them. Whoever ſhall pretend that any particular kind of manure may be uſed, with equal benefit, in graſs-land, corn-fields, vineyards, orchards, kitchen-gardens, &c. ought to be claſſed amongſt thoſe quacks who undertake to cure all perſons with the ſame remedy, without any regard to their age, conſtitution, &c. It is probably from not having paid ſufficient attention to the forementioned diſtinctions, that ſome authors have found fault with particular manures, while others have ſpoken too highly in their favour. He thinks, however, and we agree with him, that we are ſtill in want of a courſe of comparative experiments upon the various kinds of manures, conſidered according to their influence with reſpect to different ſoils, ſituations, and productions. If this part of rural economy were better underſtood, we ſhould perhaps ſee many places in a ſtate of cultivation, which, on account of the bad quality of their ſoil, have hitherto reſiſted all our endeavours to render them fertile.

Perhaps it would not be proper to diſmiſs this ſubject without noticing Mr Middleton's obſervations on various kinds of manure, which were publiſhed in the Tranſactions of the Society of Arts for the year 1799. This gentleman agrees with Mr Parmentier in recommending the *extrementitious matter of privies* as the moſt powerful of all manures on ſome kinds of ſoil; but he differs from him, and we believe from moſt writers on agriculture, when he affirms, that *wood aſhes*, when ſpread on the graſs in February or March, are of very little ſervice, and that the aſhes of *coal* and even of *peat* are of none upon any kind of land. He likewiſe affirms *ſoot* to be of very little value as a manure, *ſoapmakers waſte* to be of none, or rather to be hurtful; and he ſeems to conſider *malt-duſt*, including the duſt from the malt-kilns, to be, after the ſoil of privies, one of the moſt powerful manures. He affirms, from his own experience, that, with reſpect to fertiliſing power, the ſoil of privies, compared with farm-yard dung, is in the proportion of five to one.

MAQUANA, one of that cluſter of iſlands in the South Sea which were diſcovered by M. Bougainville, and by him named Navigator's Iſlands. It was viſited by La Perouſe in 1787, who deſcribes it as exceedingly rich in every animal and vegetable production neceſſary to the ſuſtenance of man. The two frigates which he commanded had no ſooner approached the ſhore, than he diſcovered at the bottom of each creek a number of villages, from whence came innumerable canoes, laden with hogs, cocoa nuts, and other fruits, which were purchaſed for glaſs ware. This was in the evening; and next morning the commerce was renewed in the moſt friendly manner. As early as the dawn of day, the iſlanders had ſurrounded the two frigates with 200 canoes full of different kinds of proviſion, which they would exchange only for beads—in their eſtimation diamonds of the firſt water. Axes, cloth, and all other articles of commerce, they diſdained. Abounding in real bleſſings, they were deſirous of obtaining ſuperfluities alone.

Maouna.

Two boats, filled with empty caſks, were ſent aſhore for freſh water; and Perouſe himſelf accompanied them in his pinnace. A line of ſoldiers was poſted between the beach and the Indians, who amounted to about 200, including a great many women and children. The French commander prevailed upon them all to ſit down under cocoa trees, that were not more than eight toiſes diſtant from the ſhips boats. Each of them had by him fowls, hogs, parrots, pigeons, or fruit, and all wiſhed to ſell them at once, which occaſioned ſome confuſion.

The women, ſome of whom were very pretty, offered their favours, as well as their fowls and fruit, to all thoſe who had beads to give them; and ſoon tried to paſs through the line of ſoldiers, who oppoſed but a feeble reſiſtance to their attempts. Europeans who have made a voyage round the world, eſpecially Frenchmen, have no arms to ward off ſimilar attacks. Accordingly the fair ſavages found little difficulty in breaking the ranks; the men then approached; and the confuſion was growing general; when Indians, who ſeemed to be chiefs, made their appearance with ſticks in their hands, and reſtored order, every one returning to his poſt, and the traffic beginning anew, to the great ſatisfaction of both buyers and ſellers.

While all this was paſſing with the greateſt tranquillity, and the caſks were filling with water, Perouſe thought he might venture to the diſtance of 200 yards to viſit a charming village, ſituated in the midſt of a wood, or rather of an orchard, all the trees of which were loaded with fruit. The houſes were placed upon the circumference of a circle, of about 150 toiſes in diameter, the interior forming a vaſt open ſpace, covered with the moſt beautiful verdure, and ſhaded by trees, which kept the air delightfully cool. Women, children, and old men, accompanied him, and invited him into their houſes. They ſpread the fineſt and freſheſt mats upon a floor formed of little choſen pebbles, and raiſed about two feet above the ground, in order to guard againſt humidity. He went into the handſomeſt of theſe huts, which probably belonged to a chief; and great was his ſurpriſe to ſee a large cabin of lattice-work, as well executed as any of thoſe in the environs of Paris. The beſt architect could not have given a more elegant curve to the extremities of the ellipſis that terminated the building; while a row of pillars, at five feet diſtance from each other, formed a complete colonnade round the whole. The pillars were made of trunks of trees very neatly wrought, and between them were fine mats laid over one another with great art, like the ſcales of a fiſh, and drawing up and down with cords, like our Venetian blinds. The reſt of the houſe was covered with leaves of the cocoa palm.

This charming country combines the advantages of a ſoil fruitful without culture, and of a climate which renders clothing unneceſſary. The trees that produce the bread-fruit, the cocoa-nut, the banana, the guava, and the orange, hold out to theſe fortunate people an abundance of wholeſome food; while the fowls, hogs, and dogs, which live upon the ſurplus of theſe fruits, afford them an agreeable variety of viands. What cold imagination could ſeparate the idea of happineſs from ſo enchanting a place! But Maouana is not the abode of innocence. No arms were indeed perceived; but the bodies of the Indians, covered over with ſcars, proved that they were often at war, or elſe quarrelling among themſelves; while their features announced a ferocity that was not perceptible in the countenances of the women. Nature had, no doubt, ſtamped this character on their faces, by way of ſhewing, that the half ſavage, living in a ſtate of anarchy, is a more miſchievous being than the moſt ferocious of the brute creation.

Of their ferocity and their treachery, Perouſe had too ſoon the moſt complete evidence. M. de Langle, the ſecond in command, went aſhore for freſh water, accompanied by ſixty Frenchmen, officers, ſailors, and ſoldiers. They were received with an air of good humour by crowds of people waiting on the beach with immenſe quantities of fruit and hogs; but this calm was of ſhort duration. The Indians picked a quarrel with them, pelted them with ſtones, thrown with great dexterity and with equal force; and it was with difficulty that, of the ſixty-one, forty-nine reached the ſhips, many of whom were ſeverely wounded. Among the killed were De Langle, and Lamanon the naturaliſt (See Lamanon in this *Suppl.*). Perouſe deſcribes the men of Maouana as of gigantic ſtature, and of great muſcular ſtrength. See *Navigators Iſlands* in this *Suppl.*

MASON (the Rev. William) was a man of ſuch eminence both as a poet and as a ſcholar, that a more particular account of his life and of his ſtudies ſhould be publiſhed than our ſcanty materials enable us to give. He was born at Hull, where his father poſſeſſed the vicarage of St Trinity; but where he received his ſchool education we have not been able to learn. At the proper time he was admitted into St John's College, Cambridge; where he took the degrees of B. A. and M. A. and in 1747, he obtained a fellowſhip in Pembroke Hall. It was there that he contracted an intimate friendſhip with Gray the poet, and with Mr Hurd, now Biſhop of Worceſter. When the former of theſe gentlemen died, Mr Maſon took upon himſelf the office of editor of his works and guardian of his fame; and upon the promotion of the latter to the ſee of Litchfield and Coventry, he expreſſed his ſatisfaction in ſome beautiful verſes, which we read at the time, but do not recollect where.

In 1754 he entered into holy orders, and was patronized by the then Earl of Holderneſs, who obtained for him the appointment of chaplain to the king, and preſented him with the valuable rectory of Aſton in Yorkſhire. He was ſome time afterwards made precentor of York Cathedral, when he publiſhed a ſmall volume of church muſic, which has alternately met with oppoſition and applauſe. In our opinion ſome of his anthems are unrivalled.

It was natural for the precentor of a cathedral church, who was likewiſe a poet, to turn his attention to ſacred muſic; and Maſon had been a poet from his early years. His *Elfrida* and *Caractacus*, two tragedies on the Grecian model, were both publiſhed before the year 1757. Theſe two dramas, in the opinion of Dr Hurd, do honour to modern poetry, and are, according to him, a ſufficient proof of the propriety of reviving the chorus on the Britiſh ſtage. In this ſentiment few critics, we believe, will agree with his Lordſhip; but the tragedies have certainly great merit, and tranſcend perhaps every poem of the ſame caſt in our own or any other modern tongue. In the firſt, the language is elegant and ſweet; in the latter, it is daring and ſublime. The author himſelf always conſidered the former as the moſt perfect; and Johnſon, whoſe critical judgment will not be raſhly queſtioned, ſeems to have been of the ſame opinion. Johnſon's partiality to Oxford, as is well known, made him embrace every opportunity of turning into ridicule Cambridge men and Cambridge poems; but while he boaſted of having ſpent hours in burleſquing Caractacus for the amuſement of his Oxford friends, he confeſſed that Elfrida was too beautiful to be hurt by ridicule. The voice of the public, however, ſeems to give the preference to the latter, and to conſider it as ſtanding, like Dryden's celebrated ode, without a rival. In both are ſentiments and expreſſions which would do honour to the genius of Shakeſpeare; and Caractacus, in the Greek verſion of Mr Glaſs, would not have diſgraced an Athenian theatre.

Beſides his two tragedies, Mr Maſon publiſhed many other poems. His Engliſh Garden is univerſally read and admired, being unqueſtionably the fineſt poem of the kind that has appeared ſince the days of Thomſon; though ſome have affected to conſider it as treating the ſubject rather with profeſſional ſkill than with poetical genius. That there are in it a few proſaic expreſſions we ſhall not controvert; for ſuch ſeem inſeparable from didactic poetry; but, taken as a whole, where ſhall we find its equal? His elegies, particularly that on the death of his wife, and that on the demiſe of Lady Coventry, have been generally read and extolled, though not more than they deſerve, as ſuperior in claſſic elegance to any thing of the kind in the Engliſh tongue, and expreſſing a manlineſs and tenderneſs of the pathetic, rarely found in the moſt poliſhed elegies of Roman writers. The ſplendor of genius, and accuracy of judgement, conſpicuous in his dramas, are equally diſplayed in his character as a lyric writer. His quarry was bold and impetuous, and he never ſwept the ground with an ignominious flight. In his Sappho and Phaon he has happily imitated the ſtyle of Dryden and Metaſtaſio; and at his death he was employed on a poem in which he propoſed to meaſure his ſtrength with Dryden.

We have reaſon to believe that this ingenious man was not only a poet and a muſical performer, but the inventor of the faſhionable inſtrument the Piano Forte. We cannot indeed at preſent bring evidence of this fact; but we have inſtituted ſuch inquiries as, we hope, ſhall enable us to aſcertain the truth under the article *Piano Forte.*

Poetry and muſic, and the duties of his office, might be ſuppoſed to have employed all his time; but, unfortunately, he caught the alarm which in 1769 was ſpread over the nation by the expulſion of Mr Wilkes from the Houſe of Commons, and immediately inrolled himſelf among the ſupporters of the *Bill of Rights.* The deciſion of the Houſe, which pronounced Mr Lutteral duly elected in oppoſition to Mr Wilkes, he conſidered as a groſs violation of the rights of the people; and though he ſurely did not approve of the conduct of the exiled member, he joined with other freeholders in Yorkſhire in a petition to the king that he would diſſolve the parliament.

Being now leagued with the oppoſition, he joined in ſome violent clamours for a parliamentary reform. In the year 1779, when the city of London, and ſome other commercial towns, agreed to preſent their petitions to parliament for a more economical expenditure of the public money, and a more equal repreſentation of the people, Mr Maſon came forward, and took an active part in promoting theſe deſigns, as one who was convinced of their importance and neceſſity. When the county of York aſſembled, on the 30th of December 1779, and reſolved unanimouſly, "that a committee of correſpondence ſhould be appointed, for the effectually promoting the object of the petition then agreed to, and alſo to prepare a plan of *aſſociation* to ſupport that laudable reform, and ſuch other meaſures as may conduce to reſtore the *freedom of parliament*," he was choſen upon the committee, and was conſulted with, or aſſiſted in drawing up thoſe various high-ſpirited reſolutions and addreſſes to the public, for which the Yorkſhire committee was ſo celebrated; and which was afterwards generally adopted by the other aſſociated bodies of reformers. This part of his conduct is ſurely entitled to no praiſe. Thinking as we do of the parliamentary reformers, we cannot but regret that a man of Mr Maſon's talents and virtues ſhould have embarked in their dangerous purſuits; and though we perceived leſs hazard in thoſe purſuits than we do, we ſhould ſtill conſider them as unſuitable to the character of a clergyman. Our author, however, was of a different opinion. In reply to a cenſure paſſed by a dignified clergyman on the political conduct of himſelf and ſome of his reverend brethren, he publiſhed, without his name indeed, a ſpirited defence of their proceedings and deſigns in ſome of the country papers. The York committee, too, at its next meeting, reſolved, "that a Proteſtant, by entering into holy orders, does not abandon his civil rights;" they alſo reſolved, "that the thanks of the committee be given to thoſe reverend gentlemen who, thus preferring the public good to their own private emoluments, have ſtood forth the firm friends to the true intereſts of their country."

Mr Maſon, however, ſhowed, by his ſubſequent conduct, that however earneſtly he might wiſh for what he doubtleſs conſidered as an expedient reform in the commons-houſe of Parliament, he was firmly attached to the Britiſh conſtitution. He was indeed a whig; but he was a whig of the old ſchool. In the beginning of 1794, when the reformers had betrayed the principles of French democrates, he deſerted them, and ranged himſelf under the banners of the ſervants of the crown; and for this conduct, which was certainly conſiſtent, he has been plentifully traduced by our Jacobin journaliſts as an alarmiſt, who not only deſerted his old friends, but aſcribed to them a certain degree of guilt and political depravity.

The death of this great and good man, which happened in April 1797, was occaſioned neither by age nor by inveterate diſeaſe. As he was ſtepping into his chariot, his foot ſlipped, and his ſhin grazed againſt the ſtep. This accident had taken place ſeveral days before he paid the proper attention to it; and on April the 3d a mortification enſued, which, in the ſpace of forty-eight hours, put a period to his life.

That he was a ſcholar and a poet of high eminence is univerſally acknowledged; and we are aſſured, that his poſthumous works, when publiſhed, will not detract from his living fame. In private life, though he affected perhaps too much the faſtidious manners of Mr Gray, whoſe genius he eſtimated with a degree of enthuſiaſm amounting almoſt to idolatry, his character was diſtinguiſhed by philanthropy and the moſt fervid friendſhips; and he may be conſidered as a man who merits to be ranked with the ableſt ſupporters of Britiſh liberty and Britiſh morals.

FREE-MASONRY, is a ſubject which, after the copious detail given in the *Encyclopædia* of its lodges, and wardens, and grand maſters, we ſhould not have reſumed in this place, but to warn our countrymen againſt the pernicious ſuperſtructures which have been raiſed by the French and Germans on the ſimple ſyſtem of Britiſh maſonry.

Much falſehood is current reſpecting the origin and antiquity of the maſonic aſſociations. That the Dionyſiacs of Aſia Minor were a ſociety of architects and engineers, who had the excluſive privilege of building temples, ſtadia, and theatres, under the myſterious tutelage of Bacchus, ſeems to be unqueſtionable. "We are alſo certain, that there was a ſimilar trading aſſociation during the dark ages in Chriſtian Europe, which monopolized the building of great churches and caſtles, and enjoyed many privileges under the patronage of the various ſovereigns. Circumſtances (ſays Dr Robiſon), which it would be tedious to enumerate and diſcuſs, continued this aſſociation longer in Britain than on the continent;" but there is no good evidence, that, anterior to the year 1648, any man ſought admiſſion into it, who was not either a builder by profeſſion, or at leaſt ſkilled in the ſcience of architecture. At that period, indeed, Mr Aſhmole, the famous antiquary (ſee ASHMOLE, *Encycl.*), was admitted into a lodge at Warrington, together with his father-in-law Colonel Mainwaring; and theſe are the firſt diſtinct and unequivocal inſtances that we have in Britain of men unconnected with the operative maſons being received into their myſterious fraternity. The ſecrecy, however, of the lodges, made them fit places for the meetings of the royaliſts; and accordingly many royaliſts became free-maſons. "Nay, the ritual of the maſter's degree ſeems to have been formed, or perhaps twiſted from its original inſtitution, ſo as to give an opportunity of ſounding the political principles of the candidate, and of the whole brethren preſent. For it bears ſo eaſy an adaptation to the death of the king, to the overturning of the venerable conſtitution of the Engliſh government of three orders by a mean democracy, and its re-eſtabliſhment by the efforts of the loyaliſts, that this would ſtart into every perſon's mind during the ceremonial, and could hardly fail to ſhew, by the countenances and behaviour of the brethren, how they were affected."

This ſuppoſition receives much countenance from the well known fact, that "Charles II. was made a maſon, and frequented the lodges. It is not unlikely, that beſides the amuſement of a vacant hour, which was always agreeable to him, he had pleaſure in meeting with his loyal friends, and in the occupations of the lodge, which recalled to his mind their attachment and ſervices. His brother and ſucceſſor James II. was of a more ſerious and manly caſt of mind, and had little pleaſure in the frivolous ceremonies of maſonry. He did not frequent the lodges. But, by this time, they were the reſort of many perſons who were not of the profeſſion, or members of the trading corporation. This circumſtance, in all probability, produced the denominations of *free* and *accepted* maſons. A perſon who has the privilege of working at any incorporated trade, is ſaid to be a *freeman* of that trade. Others were *accepted* as brethren, and admitted to a kind of honorary freedom; as is the caſe in many other trades and incorporations, without having (as far as we can learn for certain) a legal title to earn a livelihood by the exerciſe of it."

It was not till ſome years after this period that the lodges made open profeſſion of the cultivation of general benevolence, and that the grand aim of the fraternity was to enforce the exerciſe of all the ſocial virtues. The eſtabliſhment of a fund for the relief of unfortunate brethren did not take place till the very end of the laſt century; and we may preſume, that it was brought about by the warm recommendations of ſome benevolent members, who would naturally enforce it by addreſſes to their aſſembled brethren. Hence the probable origin of thoſe philanthropic diſcourſes, which are occaſionally delivered in the lodges by one of the brethren as an official taſk.

The boaſted philanthropy of maſons ſerves, however, another purpoſe. The inquiſitive are always prying and teazing, eager to diſcover the ſecrets of their neighbours; and hence the brethren are induced to ſay, that univerſal beneficence is the great aim of the order, for it is the only point on which they are at liberty to ſpeak. They forget, that univerſal beneficence and philanthropy are inconſiſtent with the excluſive and monopolizing ſpirit of an aſſociation, which not only confines its benevolence to its own members (like any other charitable aſſociation), but hoards up in its boſom ineſtimable ſecrets, whoſe natural tendency, they ſay, is to form the heart to this generous and kind conduct, and inſpire us with love to all mankind. The profane world cannot ſee the beneficence of concealing from public view a principle or a motive which ſo powerfully induces a maſon to be good and kind. The brother ſays, that publicity would rob it of its force; and we muſt take him at his word: and our curioſity is ſo much the more excited, to learn what are the ſecrets which have ſo ſingular a quality, for they muſt be totally unlike the principles of ſcience, which produce their effects only when made public.

From this account of maſonry, it would appear to have been at firſt a loyal aſſociation, and as ſuch it was carried over from England to the continent; for all the maſons abroad profeſs to have received their myſteries from Great Britain. It was firſt tranſported into France by the zealous adherents of King James, who, together with their unfortunate maſter, took refuge in that country; and it was cultivated by the French in a manner ſuited to the taſte and habits of that highly poliſhed and frivolous people. To the three ſimple Britiſh degrees of *apprentice*, *fellow-craft*, and *maſter*, they gradually added degrees innumerable, all decorated with ſtars and ribbons; and into their lodges they introduced the impieties and ſeditious doctrines of Voltaire and the other philoſophiſts. Indeed, if the account which the Abbé Barruel gives of maſonry be juſt, it muſt be admitted, that even the ſecrets of the moſt ancient lodges, though in one ſenſe harmleſs and juſt, are ſo expreſſed, that they may be eaſily twiſted to very dangerous purpoſes. This author was advanced by a few friends to the degree of maſter, without being obliged to take the oath of ſecrecy; and being furniſhed with the ſigns, he got admiſſion into a lodge, where he heard the ſecret regularly communicated, with all the ordinary forms, to an apprentice. "It would be uſeleſs, ſays he, to deſcribe the ceremonials and trials on ſuch occaſions; for in the firſt degrees, they are nothing more than the play of children. The grand object was the communication of the famous ſecret, when the candidate was ordered to approach nearer to the venerable. At that moment, the brethren, who had been armed with ſwords for the occaſion, drawing up in two lines, held their ſwords elevated, leaning the points towards each other, and formed what in maſonry is called the *arch of ſteel*. The candidate paſſed under this arch to a ſort of altar elevated on two ſteps, at the fartheſt end of the lodge. The maſter, ſeated in an arm chair, or a ſort of throne, behind this altar, pronounced a long diſcourſe on the inviolability of the ſecret which was to be imparted, and on the danger of breaking the oath which the candidate was going to take. He pointed to the naked ſwords, which were always ready to pierce the breaſt of the traitor; and declared to him that it was impoſſible to eſcape their vengeance. The candidate then ſwore, "that rather than betray the ſecret, he conſented to have his head cut off, his heart and entrails torn out, and his aſhes caſt before the winds." Having taken the oath, the maſter ſaid the following words to him: "My dear brother, the ſecret of maſonry conſiſts in theſe words, EQUALITY AND LIBERTY; *all men are equal and free; all men are brethren.*" The maſter did not utter another ſyllable, and every body embraced the new *brother equal and free*. The lodge broke up, and we gayly adjourned to a maſonic repaſt."

In the Britiſh lodges, the author admits, that no other interpretation is given to this famous ſecret, than that, as all men are children of one common parent, and creatures of the ſame God, they are in duty bound to love and help each other as brethren; but he contends, that in France it was differently interpreted; and he ſupports his opinion by the following arguments:

On the 12th of Auguſt 1792, Louis XVI. was carried a priſoner to the tower of the *temple*, ſo called becauſe it formerly belonged to the knights templars. On that day, the rebel aſſembly decreed, that to the date of *liberty* the date of *equality* ſhould be added in future in all public acts; and the decree itſelf was dated the fourth year of *liberty*, the firſt year and firſt day of *equality*. It was on that day, for the firſt time, that the ſecret of free-maſonry was made public; that ſecret ſo dear to them, and which they preſerved with all the ſolemnity of the moſt inviolable oath. At the reading of this famous decree, they exclaimed, "We have at length ſucceeded, and France is no other than an immenſe lodge. The whole French people are free maſons, and the whole univerſe will ſoon follow their example."

"I witneſſed (ſays our author) this enthuſiaſm; I heard the converſations to which it gave riſe; I ſaw maſons, till then the moſt reſerved, who freely and openly declared, 'Yes, at length the grand object of free-maſonry is accompliſhed, EQUALITY and LIBERTY; *all men are equal and brothers; all men are free.* That was the whole ſubſtance of our doctrine, the object of our wiſhes, *the whole of our grand ſecret!*'"

This is a very ſerious charge againſt the original ſecret of maſonry, as it was underſtood in France; and though the author does not bring it directly againſt the ſame ſecret as underſtood in Britain, he yet ſeems to ſay, that in *all* lodges, the following queſtion is put to the candidate before he is entruſted with any ſecret:— "Brother, are you diſpoſed to execute all the orders of the grand-maſter, though you were to receive contrary orders from a king, an emperor, or any other ſovereign whatever?" And as the brother is obliged to promiſe this unlimited obedience, it is eaſy to conceive how much a traiterous conſpiracy may be promoted by means of maſon lodges. The allegorical ſtory which is told at the conferring of the degree of maſter, is capable of various and even contrary interpretations; for though in this country it was originally rendered ſubſervient to the purpoſes of the royaliſts, in the occult lodges on the continent it has been made the vehicle of treaſon and impiety.

When the degree of maſter-maſon is to be conferred, the lodge is hung round with black. In the middle is a coffin covered with a pall, the brethren ſtanding round it in attitudes denoting ſorrow and revenge. When the new adept is admitted, the maſter relates to him the following hiſtory or fable:

"Adoniram preſided over the payment of the workmen who were building the temple by Solomon's orders. They were three thouſand workmen. That each one might receive his due, Adoniram divided them into three claſſes, apprentices, fellow-crafts, and maſters. He entruſted each claſs with a word, ſigns, and a gripe, by which they might be recogniſed. Each claſs was to preſerve the greateſt ſecrecy as to theſe ſigns and words. Three of the fellow-crafts, wiſhing to know the word, and by that means obtain the ſalary, of maſter, hid themſelves in the temple, and each poſted himſelf at a different gate. At the uſual time when Adoniram came to ſhut the gates of the temple, the firſt of the three met him, and demanded the *word of the maſters;* Adoniram refuſed to give it, and received a violent blow with a ſtick on his head. He flies to another gate, is met, challenged, and treated in a ſimilar manner by the ſecond: flying to the third door, he is killed by the fellow-craft poſted there, on his refuſing to betray the word. His aſſaſſins buried him under a heap of rubbiſh, and marked the ſpot with a branch of acacia.

"Adoniram's abſence gave great uneaſineſs to Solomon and the maſters. He is ſought for every where: at length one of the maſters diſcovers the corpſe, and, taking it by the finger, the finger parted from the hand; he took it by the wriſt, and it parted from the arm; when the maſter, in aſtoniſhment, cried out, *Mac Benac;* which the craft interprets by "*the fleſh parts from the bones.*"

"Leſt Adoniram ſhould have revealed the *word*, the maſters convened and agreed to change it, and to ſubſtitute the words *Mac Benac;* ſacred words, that free-maſons dare not pronounce out of the lodges, and there each only pronounces one ſyllable, leaving his neighbour to pronounce the other."

The hiſtory finiſhed, the adept is informed, that the object of the degree he has juſt received is to recover the word loſt by the death of Adoniram, and to revenge this martyr of the maſonic ſecrecy. The generality of maſons, looking upon this hiſtory as no more than a fable, and the ceremonies as puerile, give themſelves very little trouble to ſearch farther into theſe myſteries.

Theſe ſports, however, aſſume a more ſerious aſpect when we arrive at the degree of elect (*Elu*). This degree is ſubdivided into two parts; the firſt has the revenging of Adoniram for its object, the other to recover the *word*, or rather the ſacred doctrine which it expreſſed, and which has been loſt.

In this degree of elect, all the brethren appear dreſſed in black, wearing a breaſt-piece on the left ſide, on which is embroidered a death's head, a bone, and a poignard, encircled by the motto of *Conquer or die*. The ſame motto is embroidered on a ribband which they wear in ſaltier. Every thing breathes death and revenge. The candidate is led into the lodge blindfolded, with bloody gloves on his hands An adept with a poignard in his hand threatens to run him through the heart for the crime with which he is accuſed. After various frights, he obtains his life, on condition that he will revenge the father of maſonry in the death of his aſſaſſin. He is ſhewn to a dark cavern. He is to penetrate into it; and they call to him, Strike all that ſhall oppoſe you; enter, defend yourſelf, and avenge our maſter; at that price you ſhall receive the degree of elect. A poignard in his right hand, a lamp in his left, he proceeds; a phantom oppoſes his paſſage; he hears the ſame voice repeat, Strike, avenge Hiram, there is his aſſaſſin. He ſtrikes, and the blood flows.—Strike off his head, the voice repeats; and the head of the corpſe is lying at his feet. He ſeizes it by the hair (A), and triumphantly carries it back as a proof of his victory; ſhows it to each of the brethren, and is judged worthy of the new degree.

Our author ſays, that he has queſtioned divers maſons whether this apprenticeſhip to ferocity and murder had never given them the idea, that the head to be cut off was that of kings; but they all affirmed that ſuch an idea had never occurred to them till the French revolution had convinced them of the fact. At this indeed we are not ſurpriſed. The aſſaſſin of Hiram is no where ſaid to have been a king; and why ſhould the young elect have ſuppoſed, that when ſtabbing that aſſaſſin, he was training to be a regicide? The ceremony, however, is certainly ferocious in the higheſt degree, and obviouſly calculated to reconcile the maſons of the occult lodges to the practice of aſſaſſination at the command of their ſuperiors; and when it is remembered, that they are bound to pay obedience to thoſe unſeen ſuperiors even againſt their lawful ſovereigns, the atrocities of the revolution would naturally make them interpret this ſhocking ceremony as it is interpreted by the Abbé.

It was the ſame with reſpect to the religious part of this degree, where the adept is at once pontiff and ſacrificer with the reſt of the brethren. Veſted in the ornaments of the prieſthood, they offer bread and wine, according to the order of Melchiſedec. The ſecret object of this ceremony is to re-eſtabliſh religious equality, and to exhibit all men equally prieſts and pontiffs, to recal the brethren to natural religion, and to perſuade them that the religion of Moſes and of Chriſt had violated religious equality and liberty by the diſtinction of

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(A) The reader may eaſily conceive that this corpſe is no more than a mannikin containing bladders full of blood.

of prieſts and laity. It was the revolution again which opened the eyes of many of the adepts, who then owned that they had been dupes to this impiety, as they had been to the regicide eſſay in the former part.

Our author treats the fraternity of the occult lodges through the higher degrees of Scotch maſonry, thoſe of the Roſicrucians, and that of the knights Kadoſch; and ſums up his account in the following terms:

" In the two firſt degrees, that is to ſay, in thoſe of *apprentice* and *fellow-craft*, the ſect begins by throwing out its equality and liberty. After that, it occupies the attention of its novices with puerile games of fraternity or maſonic repaſts; but it already trains its adepts to the profoundeſt ſecrecy by the moſt frightful oaths.

" In that of *maſter*, it relates the allegorical hiſtory of Adoniram, who is to be avenged; and of the *word*, which is to be recovered.

" In the degree of *elect*, it trains the adepts to vengeance, without pointing out the perſon on whom it is to fall. It carries them back to the time of the patriarchs, when, according to them, men knew no religion but that of nature, and when every body was equally prieſt and pontiff. But it had not as yet declared that all religion revealed ſince the time of the patriarchs was to be thrown aſide.

" This laſt myſtery is only developed in the Scotch degrees. There the brethren are declared free: The word ſo long ſought for is, Deiſm; it is the worſhip of Jehovah, ſuch as was known to the philoſophers of nature. The true maſon becomes the pontiff of Jehovah; and ſuch is the grand myſtery by which he is extricated from that darkneſs in which the prophane are involved.

" In the degree *Roſæ Crucis*, he who wreſted the *word*, who deſtroyed the worſhip of Jehovah, is Chriſt himſelf, the author of Chriſtianity; and it is on the Goſpel and on the Son of Man that the adept is to avenge the brethren, the pontiffs of Jehovah.

" At length, on his reception as Kadoſch, he learns that the aſſaſſin of Adoniram is the king, who is to be killed to avenge the grand maſter Molay, and the order of the maſons ſucceſſors of the knights templars. The religion which is to be deſtroyed to recover the *word*, or the true doctrine, is the religion of Chriſt, founded on revelation. This word in its full extent is *equality* and *liberty*, to be eſtabliſhed by the total overthrow of the altar and the throne.

" Such are the incipient degrees, the proceſs, and the whole ſyſtem of maſonry; it is thus that the ſect, by its gradual explanation of its twofold principle of *equality* and *liberty*, of its allegory of the founder of maſonry to be avenged, of the word to be recovered, leading the adepts from ſecret to ſecret, at length initiates them into the whole Jacobinical code of revolution."

If this account of maſonry be not greatly exaggerated, what are we to think of thoſe men among ourſelves, who, ſince the publication of the Abbé Barruel's book and Dr Robiſon's, have diſplayed a zeal for the propagation of their myſteries, by which they ſeemed not to be formerly actuated, and to which the importance of the buſineſs that, by their own account, is tranſacted in the lodges, cannot be thought to bear an adequate proportion? It is not enough to ſay that Britiſh maſonry is harmleſs, and that the *equality* and *liberty* taught in our lodges are the equality and liberty taught in the bible. Without directly queſtioning this aſſertion, we only beg leave to put our countrymen in remembrance, that French and German maſonry, as it was derived from Britain, muſt have been originally as harmleſs as our own; and to call their attention to the monſtrous ſuperſtructures of impiety and rebellion which in theſe countries have been raiſed upon our foundation. Have there been no ſymptoms of ſedition and irreligion among us, ſince the commencement of the French revolution, that we ſhould be ſo confident that the equality and liberty of our lodges will never degenerate into the equality and liberty of the French Jacobins? This cannot be ſaid; for it has been proved, that there are ſeveral occult lodges in Britain; and what ſecurity have we, or what ſecurity can we receive, that their number will not increaſe? The legiſlature indeed has lately laid ſome ſalutary reſtraints on the meetings of maſons; but ſuch is the nature of theſe meetings, that nothing can effectually ſecure us againſt the introduction of the higher myſteries, but the voluntary ſhutting up for a time of all lodges. This has been done by the honeſt maſons in Germany; and why may it not be done by the maſons in Britain? The fund for the relief of poor brethren may ſurely be managed without ſecrecy; the ſigns and gripe may be communicated without the *word*, or exacting a promiſe of implicit obedience; and the relinquiſhing of the joys of a ſocial hour would be no great ſacrifice to the peace of a country.

But is Britiſh maſonry really ſo harmleſs as the younger maſons wiſh us to believe? The writer of theſe reflections was never initiated in its myſteries, and therefore cannot, from his own knowledge, ſay what is their tendency; but he has no heſitation to affirm, becauſe he believes himſelf able to demonſtrate, that it is groſsly immoral to promiſe implicit obedience to unknown ſuperiors, or to ſwear that one will keep inviolate a ſecret, to the nature of which he is an abſolute ſtranger. He hopes, indeed, and is inclined to believe, that, in the decent lodges of Britain, the candidate is aſſured, before he is required to take the oath, that the ſecret to be communicated, and the obedience which he is to pay, militate in no reſpect againſt the civil government or the religion of his country; but ſtill if the ſecret contain information of value, it is, in his opinion, ſinful to keep it a ſecret; and he cannot conceive upon what principle a native of Britain can promiſe unlimited obedience to any human being. The myſteries of maſonry muſt relate to ſomething which is either important and laudable; frivolous, though innocent; or dangerous and immoral. To confine to a ſect any information which is laudable and important, is ſurely not to act the part of genuine philanthropiſts; to adminiſter the moſt tremendous oaths in the midſt of frivolous amuſements, is to violate one of the moſt ſacred precepts of our holy religion; and, as no man will pretend to vindicate dangerous and immoral myſteries, maſonry appears, in every point in which it can be placed, an aſſociation which no good Chriſtian will think himſelf at liberty to encourage.

MASUAH (See Massuah, *Encycl.*) is in latitude 15° 35′ 5″ north, and in longitude 39° 36′ 30″ eaſt of Greenwich. On the 22d of September 1769 Mr Bruce found the variation of the needle at Maſuah to be 12° 45′ weſt.

MATMAI, or Matsumai, is the largeſt of the Kurile iſlands; and if it be not independent, is tributary to Japan. The capital town of the ſame name, Matmai, is ſituated on the ſea-ſhore, on the ſouth-weſt ſide. It was built and is inhabited by the Japaneſe. It is a fortified place, furniſhed with artillery, and defended by a numerous garriſon. The iſland of Matmai is the place of exile for perſons of diſtinction at Japan: it is ſeparated from that empire by only a narrow channel, but which is conſidered as dangerous, becauſe the capes, which project on both ſides, render the navigation difficult. The people are ſaid to be ſenſible to friendſhip, hoſpitable, generous, and humane.

MAYORGA (Martin de). See *Don Martin*, &c. in this *Suppl.*

MAYOW (John), whoſe diſcoveries in chemiſtry have aſtoniſhed the ſcientific part of the public, deſcended, ſays Wood, from a genteel family living at *Bree* in the county of *Cornwall*. His father was probably a younger ſon, bred to buſineſs; for our author was born in Fleet-ſtreet, London, in the pariſh of St Dunſtan's in the Weſt. At what ſchool he received the rudiments of his education, a circumſtance which the biographers of men eminent in the republic of letters ſhould never omit, we have not been able to learn; but on the 27th of September 1661, when he had juſt completed his 16th year, he was admitted a ſcholar of Wadham college, Oxford. Some time afterwards, on the recommendation of Henry Coventry, Eſq; one of the ſecretaries of ſtate, he was choſen probationer fellow of All-ſouls college. As Wood informs us that he had here a *Legiſt's place*, an expreſſion by which we underſtand a law-fellowſhip, it is not wonderful that he took his degrees in the civil law, though phyſic and the phyſical ſciences were the favourite objects of his ſtudy. He was indeed an eminent phyſician, practiſing both in London and in Bath, but in the latter city chiefly in the ſummer months, till the year 1679, when he died, ſome time during the month of September, in the houſe of an apothecary in York-ſtreet, Covent Garden, and was buried in the church of that pariſh. He had been married, ſays Wood, a little before his death, not altogether to his content; and indeed he muſt have been very diſcontented, if he choſe to die in the houſe of a friend rather than in his own. He publiſhed, "Tractatus quinque medico phyſici, 1. De ſalnitro; 2. De reſpiratione; 3. De reſpiratione fœtus in utero et ovo; 4. De motu muſculari et ſpiritibus animalibus; 5. De Rachitide." Theſe were publiſhed together in 8vo at Oxford, in 1674; but there is an edition of two of them, "De reſpiratione," and "De Rachitide," publiſhed together at Leyden in 1671.

The fame of this author has been lately revived and extended by Dr Beddoes, who publiſhed, in 1790, "Chemical Experiments and Opinions, extracted from a work publiſhed in the laſt century," 8vo; in which he gives to Mayow the higheſt credit as a chemiſt, and aſcribes to him ſome of the greateſt modern diſcoveries reſpecting air, giving many extracts from the three firſt of his treatiſes. His chief diſcovery was, that oxygen gas, to which he gave the name of *fire air*, exiſts in the nitrous acid, and in the atmoſphere; which he proved by ſuch deciſive experiments, as to render it impoſſible to explain how Boyle and Hales could avoid availing themſelves, in their reſearches into air, of ſo capital a diſcovery. Mayow alſo relates his manner of paſſing aeriform fluids under water, from veſſel to veſſel, which is generally believed to be a new art. He did not collect dephlogiſticated air in veſſels, and transfer it from one jar to another, but he proved its exiſtence by finding ſubſtances that would burn in vacuo, and in water when mixed with nitre; and after animals had breathed and died in veſſels filled with atmoſpheric air, or after fire had been extinguiſhed in them, there was a reſiduum which was the part of the air unfit for reſpiration, and for ſupporting fire; and he further ſhewed, that nitrous acid cannot be formed, but by expoſing the ſubſtances that generate it to the atmoſphere. Mayow was undoubtedly no common man, eſpecially ſince, if the above dates are right, he was only 34 at the time of his death. But he was not ſo unknown as Dr Beddoes ſuppoſed; for ſince the repetition of the ſame diſcovery by Prieſtley and Scheele, reference has frequently been made by chemiſts to Mayow as the original inventor; thus allowing to him a ſpecies of merit, to which he has perhaps but a doubtful claim, and which, if that claim be well founded, muſt certainly be ſhared between him and Dr Hooke. See Hooke in this *Supplement*.

MEAN, in general. See *Encycl.*

Arithmetical Mean, is half the ſum of the extremes. So 4 is an arithmetical mean between 2 and 6, or between 3 and 5, or between 1 and 7; alſo an arithmetical mean between a and b is $\frac{a+b}{2}$, or $\frac{1}{2}a+\frac{1}{2}b$.

Geometrical Mean, commonly called a mean proportional, is the ſquare root of the product of the two extremes; ſo that, to find a mean proportional between two given extremes, multiply theſe together, and extract the ſquare root of the product. Thus, a mean proportional between 1 and 9, is $\sqrt{1\times 9}=\sqrt{9}=3$: a mean between 2 and $4\frac{1}{2}$ is $\sqrt{2\times 4\frac{1}{2}}=\sqrt{9}=3$ alſo; the mean between 4 and 6 is $\sqrt{4\times 6}=\sqrt{24}$; and the mean between a and b is $\sqrt{ab}$.

Harmonical Mean. See *Harmonical Proportion*, Encycl.

Mean and Extreme Proportion, or *Extreme and Mean Proportion*, is when a line or any quantity is ſo divided that the leſs part is to the greater, as the greater is to the whole.

Mean Anomaly of a Planet, is an angle which is always proportional to the time of the planet's motion from the aphelion or perihelion, or proportional to the area deſcribed by the radius vector; that is, as the whole periodic time in one revolution of the planet, is to the time paſt the aphelion or perihelion, ſo is 360° to the mean anomaly. See Anamoly, *Encycl.*

Mean Conjunction or *Oppoſition*, is when the mean place of the ſun is in conjunction, or oppoſition, with the mean place of the moon in the ecliptic.

Mean Diſtance of a Planet from the Sun, is an arithmetical mean between the planet's greateſt and leaſt diſtances.

Mean Motion, is that by which a planet is ſuppoſed to move equably in its orbit; and it is always proportional to the time.

Mean Time, or *Equal Time*, is that which is meaſured by an equable motion, as a clock; as diſtinguiſhed from apparent time, ariſing from the unequal motion of the earth or ſun.

Universal or Perpetual MEASURE, is a kind of meaſure unalterable by time or place, to which the meaſures of different ages and nations might be reduced, and by which they may be compared and eſtimated. Such a meaſure would be very uſeful if it could be attained; ſince, being uſed at all times, and in all places, a great deal of confuſion and error would be avoided.

It has been attempted, at different times and in different countries, more eſpecially by the French, who, ſince the commencement of their revolutionary government, have laboured hard to obtrude their innovations in arts and ſcience, as well as in politics, upon all nations. Propoſals, however, have been made by ſoberer men for a ſtandard both of weights and of meaſures for all nations; and ſome of the moſt rational of theſe ſhall be noticed under the word WEIGHTS in this *Supplement*.

MECHANICS.—Our readers will recollect that in the article PHYSICS, *Encycl.* we propoſed to diſtinguiſh by the term *Mechanical Philoſophy* that part of natural ſcience which treats of the local motions of bodies, and the cauſes of thoſe phenomena. And, although all the changes which we obſerve in material nature are accompanied by local motion, and, when completely explained, are the effects (perhaps very remote) of thoſe powers of matter which we call *moving forces*, and of thoſe alone, yet, in many caſes, this local motion is not obſerved, and we only perceive certain ultimate reſults of thoſe changes of place. This is the caſe (for example) in the ſolution of a grain of ſilver in a phial of aquafortis. In the beginning of the experiment, the particles of ſilver are contained in a ſmall ſpace at the bottom of the phial; but they are finally raiſed from the bottom, and uniformly diſſeminated over the whole fluid. If we fix our attention ſteadily on one particle, and trace it in its whole progreſs, we contemplate nothing but a particle of matter acted on by moving forces, and yielding to their action. Could we ſtate, for every ſituation of the particle, the direction and intenſity of the moving force by which it is impelled, we could conſtruct a figure, or a formula, which would tell us the preciſe direction and velocity with which it changes its place, and we could delineate its path, and tell the time when it will arrive at that part of the veſſel where it finally reſts in perfect equilibrium. Newton having done all this in the caſe of bodies acted on by the moving force called gravity, has given us a complete ſyſtem of mechanical aſtronomy. The philoſopher who ſhall be as fortunate in aſcertaining the paths and motions of the particles of ſilver, till the end of this experiment, will eſtabliſh a ſyſtem of the mechanical ſolution of ſilver in aquafortis; and the theorems and formulæ which characteriſe this particular moving force, or this modification of force, ſtating the laws of variation by a change of diſtance, will be the complete theory of this chemical fact. It is this modification of moving force which is uſually (but moſt vaguely) called the *chemical affinity*, or the *elective attraction of ſilver and aquafortis*.

But, alas! we are, as yet, far from having attained this perfection of chemical knowledge. All that we have yet diſcovered is, that the putting the bit of ſilver into the ſpirit of ſalt will not give occaſion to the exertion of this moving force; and we expreſs this obſervation, by calling that unknown force (unknown, becauſe we are ignorant of the law of its action) an *affinity*, an *elective* attraction. And we have obſerved many ſuch elections, and have been able to claſs them, and to tell on what occaſions they will or will not be exerted; and this ſcrap of the complete theory becomes a moſt valuable acquiſition, and the claſſification of thoſe ſcraps a moſt curious, and extenſive, and important ſcience. The chemical philoſopher has alſo the pleaſure of ſeeing gradual approaches made by ingenious men to the complete mechanical explanation of theſe unſeen motions and their cauſes, of which he has arranged the ultimate reſults.

The ordinary chemiſt, however, and even many moſt acute and penetrating enquirers, do not think of all theſe motions. Familiarly converſant with the reſults, they conſider them as principles, and as topics to reaſon from. They think a chemical phenomenon ſufficiently explained, when they have pointed out the affinity under which it is arranged. Thus they aſcribe the propagation of heat to the expanſive nature of fire, and imagine that they conceive clearly how the effect is produced. But if a mathematical philoſopher ſhould ſay, "What is this which you call an expanſive fluid? Explain to me diſtinctly, in what manner this property which you call expanſiveneſs operates in producing the propagation of heat."—We imagine that the chemiſt would find himſelf put to a ſtand. He will then, perhaps for the firſt time, try to form a diſtinct conception of an expanſive fluid, and its manner of operation. He will naturally think of air, and will reflect on the manner in which air actually expands or occupies more room; and he will thus contemplate local motion and mechanical preſſure. He will find, too late, that this gives him no aſſiſtance; becauſe the phenomena which he has been accuſtomed to explain by the expanſiveneſs of fluids have no reſemblance whatever to what we ſee reſult from the actual expanſion of air. Experience has made him acquainted with many effects which the air produces during its expanſion; but they are of a totally different kind from thoſe which he thought that he had ſufficiently explained by the expanſiveneſs of fire. The only reſemblance he obſerves is, that the air and the heat, which were formerly perceived only in a ſmall ſpace, now appear in a much larger ſpace. The mathematician now deſires him to tell in what manner he conceives this expanſiveneſs, or this actual expanſion of air or gas. The chemiſt is then obliged to conſider the air or gas as conſiſting of atoms or particles, which muſt be kept in their preſent ſituation by an external force, the moſt familiar of all to his imagination, namely, preſſure; and all preſſures are equally fit. Preſſure is a moving force, and can only be oppoſed to ſuch another moving force; therefore expanſiveneſs ſuppoſes, that the particles are under the influence of ſomething which would ſeparate them from each other, if it were not oppoſed by ſomething *perfectly of the ſame kind.* It cannot be oppoſed by greenneſs, nor by loudneſs, nor by fear, but only by what is competent to the production of motion; and it may be oppoſed by any *ſuch* natural power; therefore by gravity, or by magnetiſm, or electricity, or corpuſcular attraction, or by an elective attraction. The chemiſt, being thus led to the contemplation of the phenomenon in its moſt ſimple ſtate, can now judge with ſome diſtinctneſs, what is the nature of thoſe powers with which expanſiveneſs can be brought to co-operate or combine. And only now will he be able to ſpeculate on the means for explaining the propagation of heat; and he will perceive, that the general laws of motion, and of the action of moving forces (doctrines which we comprehended under the title of DYNAMICS, *Suppl.*), muſt be reſorted to for a *complete* explanation of all chemical phenomena. The ſame may be ſaid of the phenomena perceived in the growth of vegetables and animals. All of them lead us ultimately to the contemplation of an atom, which is characteriſed by being ſuſceptible of local motion, and requires for this purpoſe the agency of what we call a moving force.

We would diſtinguiſh this particular OBJECT of our CONTEMPLATION (conſiſting of two conſtituent parts, the atom and the force, related, in fact, to each other by conſtant conjunction) by the term MECHANISM. We conceive it to be the characteriſtic of what we call MATTER; and we would conſider it as the moſt ſimple MECHANICAL PHENOMENON. We are diſpoſed to think, that this moving force is as ſimple and uniform as the atom to which it is related; and we would aſcribe the inconceivable diverſity of the moving forces which we ſee around us to combinations of this univerſal force exerted by many atoms at once; and therefore modified by this combination, in the very ſame manner as we frequently ſee thoſe ſeemingly different moving forces combine their influence on a ſenſible maſs of tangible matter, giving it a ſenſible local motion. Having formed ſuch notions, we would ſay that we do not conceive either the atom or the force as being matter, but the two thus related. And we would then ſay, that whatever object of contemplation does not ultimately lead us to this complex notion is IMMATERIAL; meaning by the epithet nothing more than the negation of this particular character of the object. It is equivalent to ſaying, that the phenomenon does not lead the mind to the conſideration of an atom actuated by a moving force; that is, moved, or prevented from moving, by an oppoſite preſſure or force.

Such is the extenſion which the diſcoveries of laſt century have enabled us to give to the uſe of the term mechaniſm, mechanical action, mechanical cauſe, &c.

The Greeks, from whom we have borrowed the term, gave it a much more limited meaning; confining it to thoſe motions which are produced by the intervention of machines. Even many of the naturaliſts of the preſent day limit the term to thoſe motions which are the *immediate* conſequences of impulſe, and which are caſes of ſenſible motion. Thus the chemiſt ſays, that printers ink is a mechanical fluid, but that ink for writing is a chemical fluid. We make no objection to the diſtinction, becauſe chemiſtry is really a vaſt body of real and important ſcience, although we have, as yet, been able to claſs only very complicated phenomena, and are far from the knowledge of its elements. This diſtinction made by the chemiſts is very clear, and very proper to be kept in view; but we ſhould be at a loſs for a term to expreſs the analogy which is perceivable between theſe ſenſible motions and the hidden motions which obtain even in the chemical phenomena, unleſs we give mechaniſm a ſtill greater extenſion than the effects of percuſſion or impulſion.

Mechanics, in the ancient ſenſe of the word, conſiders only the energy of *organa*, machines. The authors who have treated the ſubject ſyſtematically, have obſerved, that all machines derive their efficacy from a few ſimple forms and diſpoſitions, which may be given to that piece of matter called the *tool*, 'Οργανον or *machine*, which is interpoſed between the workman or natural agent, and the taſk to be performed, which is always ſomething to be moved, in oppoſition to reſiſting preſſures To thoſe ſimple forms they have given the name of MECHANICAL POWERS, ſimple powers, ſimple machines.

The machine is interpoſed for various reaſons.

1. In order to enable a natural power, having a certain determinate intenſity, which cannot be increaſed, to balance or overcome another natural power, acting with a greater intenſity. For this purpoſe, a piece of ſolid matter is interpoſed, connected in ſuch a manner with firm ſupports, that the preſſure exerted on the impelled point by the power occaſions the excitement of a preſſure at the working point, which is equal or ſuperior to the reſiſtance, ariſing from the work, to the motion of that point. Thus, if a rod three feet long be ſupported at one foot from the end to which the reſiſtance of two pounds is applied, and if a preſſure of one pound be applied to the other end of the rod, perpendicular to its length, the coheſive forces which connect the particles of the rod will all be excited, in certain proportions, according to their ſituation, and the ſupported point will be made to preſs on its ſupport as much as three pounds would preſs on it; and a preſſure in the oppoſite direction will be excited at the working point, equal to the preſſure of two pounds. The reſiſtance will therefore be balanced, and it will be overcome by increaſing the natural power acting on the long diviſion of the rod. This is called a LEVER. Toothed wheels and pinions are a perpetual ſucceſſion of levers in one machine or mechanical power.

2. The natural power may act with a certain velocity which cannot be changed, and the work requires to be performed with a greater velocity. A machine is interpoſed, moveable round a fixed ſupport, and the diſtances of the impelled and working points are taken in the proportion of the two velocities. Then are we certain, that when the power acts with its natural velocity, the working point is moving with the velocity we deſire.

3. The power may act only in one unchangeable direction, and the reſiſtance muſt be overcome in another direction. As when a quantity of coals muſt be brought from the bottom of a pit, and we have no power at command but the weight of a quantity of water. We let the water pull down one end of a lever, either immediately or by a rope, and we hang the coals on the other end, while the middle point is firmly ſupported. This lever may be made perpetual, by lapping the ropes round a cylinder which turns round an axis firmly ſupported. This is a FIXED PULLEY. We can ſet unequal powers in oppoſition, by lapping each rope round a different cylinder, having the ſame axis. This is a WINDLASS OR GIN. All theſe forms derive their energy from the lever virtually contained in them.

Any of theſe three purpoſes may be gained by the interpoſition of a ſolid body in another way. Inſtead of being ſupported in one point, round which it is moveable, it may be ſupported by a ſolid path, along which it is impelled, and by its ſhape it thruſts the reſiſting body out of its way. This is the caſe with the WEDGE when it is employed to force up a ſwagging joiſt, or preſs things ſtrongly together. If this wedge be lapped or formed round an axis, it becomes a SCREW or a SPIRAL WIPER. This is alſo the operation of the balance wheel of a horizontal or cylinder watch. The oblique face of the tooth is a wedge, which thruſts the edge of the cylinder out of its way. The pallet of a clock or watch is alſo a wedge, acted on in the oppoſite direction.

Theſe are the different forms in which a ſolid body is interpoſed as a mechanic power. All are reducible to the lever and the wedge.

But there are other mechanic powers beſides thoſe now mentioned. The carmen have a way of lowering a caſk of liquor into a cellar, by paſſing a rope under it, making the end faſt to ſome ſtake cloſe to the ground, and bringing the other end of the rope round the caſk, and thus letting it ſlip down in the bight of the rope. In this proceſs they feel but half of its weight, the other half being ſupported by the end of the rope that is faſtened to the ſtake. This is called a PARBUCKLE by the ſeamen. A hanging pulley is quite the ſame with this more artleſs method. The weight hangs by the axis of the pulley, and each half of the hanging rope carries half of the weight, and the perſon who pulls one of them upwards acts only againſt half of the weight, the other being carried by the hook to which the ſtanding rope is faſtened. This mechanical power does not (as is commonly imagined) derive its efficacy from the pulley's turning round an axis. If it were made faſt, or if the tackle rope merely paſſed through a loop of the rope which carries the weight, it would ſtill require only half of the weight acting on the running rope to balance it. The uſe of the motion round an axis is merely to avoid a very great friction. When the two hanging parts of the rope are not parallel, but inclined in any angle, the force neceſſary for balancing the weight is to the weight as the ſide is to the diagonal of the parallelogram formed by the directions of the three ropes. Varignon calls this the FUNICULAR MACHINE or power. Our ſailors call it the SWIGG.

We may employ the *quaqua verſum* preſſure of fluidity with great effect as a mechanic power. Thus, in the hydroſtatic bellows deſcribed by Graveſande, § 1451, and by Deſaguiliers, the weight of a few ounces of water is made to raiſe ſeveral hundred pounds. In like manner, Dr Wallis of Oxford, by blowing with a pipe into a bladder, raiſed 64 pounds lying on it. Otto Guericke of Magdeburgh made a child balance, and even overcome, the pull exerted by the emperor's ſix coach horſes, by merely ſucking the air from below a piſton. Mr Bramah, ironmonger in Piccadilly, London, has lately obtained a patent for a machine acting on this principle as a preſs*. A piſton of one-fourth of an inch in diameter, forces water into a cylinder of 12 inches diameter, and by this intervention raiſes the piſton of the cylinder. A boy, acting with the fourth part of his ſtrength on the ſmall piſton by means of a lever, raiſes 42 tons, or 94,080 libs, preſſing on the great piſton. It is very ſurpriſing, that this application of the *quaqua verſum* preſſure of fluids has been overlooked for more than a century, although the principle has been inculcated and lectured on by every itinerant teacher, and illuſtrated by the above mentioned experiments of Graveſande and Wallis; nay, it has been expreſsly taught as a mechanic power of great efficacy by the Profeſſor of Natural Philoſophy at Edinburgh every ſeſſion of the college for theſe twenty years paſt, but he never thought of putting it in practice. It forms a moſt compendious machine of prodigious power, and is ſuſceptible of the greateſt ſtrength. If the ſame multiplication of power be attempted by toothed wheels, pinions, and racks, it is ſcarcely poſſible to give ſtrength enough to the teeth of the racks, and the machine becomes very cumberſome and of great expence. But Mr Bramah's machine may be made abundantly ſtrong in very ſmall compaſs. It only requires very accurate execution. We give it all praiſe; but Mr Bramah is miſtaken when he publiſhes it as the invention or diſcovery of a new mechanic power: for it has been familiar to every ſtudent of mechanics and hydroſtatics ever ſince Boyle's firſt publication of his hydroſtatic paradoxes.

MEDICAL JURISPRUDENCE. See *MEDICINA Forenſis* in this *Suppl.*

MEDICI, is the name of an illuſtrious family in Florence, which contributed more than perhaps any other family whatever to the revival of letters in Europe. To trace this family from its origin, or even to give biographical ſketches of all the great men whom it produced, would occupy by far too great a part of our work; for, during ſome centuries, almoſt every individual of the houſe of Medici was diſtinguiſhed among his contemporaries. That houſe, after having rendered itſelf memorable in the annals of Florence, for oppoſing the encroachments of the nobles on the liberties of the people, had loſt much of its influence under the ariſtocratic government of the Albizi, when it was raiſed to a rank ſuperior to what it had ever held, by

Giovanni de MEDICI, who was born in the year 1360. This man determined to reſtore his family to ſplendour; but, conſcious of his critical ſituation, ſurrounded as he was by powerful rivals and enemies, he affected rather a ſecure privacy than a dangerous popularity. Even when raiſed to the office of gonfalonier, or generaliſſimo of the republic, he carefully avoided any deſire of partaking in the magiſtracy, and ſeemed to be entirely engroſſed by merchandize, which he extended from the Eaſt throughout Europe. This conduct, as on one hand it threw his enemies off their guard, on the other, enabled him to acquire an immenſe fortune, of which he made a proper diſpoſition amongſt all ranks of people.

Many, even of the ruling party, either gained by his liberality, or pleaſed with his amiable and retired conduct, propoſed to the ſeigniory to admit him into the magiſtracy; and though the propoſal met with great oppoſition, it was carried in the affirmative.

It was by raſhly declaring for the plebeians againſt the nobles that an anceſtor of Giovanni's had loſt to his family their rank in the ſtate. Giovanni, reſolving not to ſplit on the ſame rock, continued to affect privacy and retirement, accepting any office in the ſtate with the utmoſt appearance of reluctance, and never attending at the Palazzo, unleſs particularly ſent for by the ſeigniory. Riſing by theſe means in the eſteem of the people, his enemies became, of courſe, unpopular; and having obtained a decided ſuperiority over his opponents, he now ventured to procure, that thoſe taxes which the nobles had exacted with the utmoſt ſeverity and partiality from the people alone, ſhould be levied

* See MACHINERY in this *Suppl.*

upon the two firſt orders, in common with the plebeians; and that a law ſhould be ordained, by which perſonal property might be taxed.

The nobles ſeeing, with the deepeſt concern, their conſequence ſo ſenſibly wounded, and their power ſo much diminiſhed, held ſeveral conſultations in private how they might effect his ruin; but their want of unanimity prevented any thing deciſive from being carried into execution. The people, alarmed for the ſafety of their leader and patron, offered him the ſovereignty, which his relations and friends urged him to accept; but this his prudence forbad him to take, as with the title of lord he would have gained alſo that of tyrant. Thus, by his ſingular prudence, he died poſſeſſed of all the power of the ſtate, with the affectation of being the moſt diſintereſted citizen in the commonwealth. His death happened in the year 1428.

Giovanni was graceful in his perſon, and his affability to all eſtabliſhed his character for moderation. His extenſive knowledge and pleaſantry made his company eagerly ſought. As all his actions were placid and ſerene, he was not in want of that trumpet of ſedition, popular declamation, which he never attempted. Much to his honour, his elevation was not procured even by the baniſhment of a ſingle individual; a circumſtance until then unknown in Florence, where every new adminiſtration was marked with the ruin of families, and by ſcaffolds ſtained with blood.

"The maxims (ſays Mr Roſcoe) which, uniformly purſued, raiſed the houſe of Medici to the ſplendour which it afterwards enjoyed, are to be found in the charge given by this venerable old man, on his deathbed, to his two ſons Coſmo and Lorenzo. 'I feel (ſaid he) that I have lived the time preſcribed me. I die content, leaving you, my ſons, in affluence and in health and in ſuch a ſtation, that, whilſt you follow my example, you may live in your native place honoured and reſpected. Nothing affords me more pleaſure than the reflection, that my conduct has given offence to no one; but that, on the contrary, I have endeavoured to ſerve all perſons to the beſt of my abilities. I adviſe you to do the ſame. With reſpect to the honours of the ſtate, if you would live with ſecurity, accept only ſuch as are beſtowed on you by the laws, and the favour of your fellow-citizens; for it is the exerciſe of that power which is obtained by violence, and not of that which is voluntarily given, that occaſions hatred and contention."

Medici (Coſmo de), the eldeſt ſon of the preceding, was born in 1389. During the life-time of his father, he had engaged himſelf deeply, not only in the extenſive commerce by which the family had acquired its wealth, but in the weightier matters of government. When Giovanni died he was in the prime of life; and though his complexion was ſwarthy, he had an agreeable perſon, was well made, of a proper ſtature, and in converſation united a happy intermixture of gravity with occaſional ſallies of pleaſantry and repartee. His conduct was uniformly marked by urbanity and kindneſs to the ſuperior ranks of his fellow-citizens, and by a conſtant attention to the intereſts and the wants of the lower claſs, whom he relieved with unbounded generoſity. By theſe means he acquired numerous and zealous partizans of every denomination; but he rather conſidered them as pledges for the continuance of the power which he poſſeſſed, than as inſtruments to be employed in extending it to the ruin and ſubjugation of the ſtate. An interchange of reciprocal good offices was the only tie by which the Florentines and the Medici were bound; and perhaps the long continuance of this connection may be attributed to the very circumſtance of its being in the power of either of the parties at any time to have diſſolved it.

But the prudence and moderation of Coſmo could not repreſs the ambitious deſigns of thoſe rival families, who wiſhed to poſſeſs or to ſhare his authority. In the year 1433, Rinaldo de Albizi, at the head of a powerful party, carried the appointment of the magiſtracy. At that time Coſmo had withdrawn to his ſeat in the country, to avoid the diſturbances which he ſaw likely to enſue; but at the requeſt of his friends he returned to Florence, where he was led to expect ſuch a union of parties, as might at leaſt preſerve the peace of the city. No ſooner did he make his appearance in the palace, where his preſence had been requeſted, on pretence of his being intended to ſhare in the adminiſtration of the republic, than he was ſeized upon by his adverſaries, and committed to priſon.

The conſpirators were divided in their opinions as to the diſpoſal of their priſoner. Moſt of them inclined to follow the advice of Peruzzi, who recommended taking him off by poiſon. Coſmo, confined in the Alberzettino, a room in one of the turrets of the Palazzo, could hear this dreadful conſultation, which was determining, not in what manner he ſhould be tried, but in what manner he ſhould be put to death; and finding that he was to die by an infuſion of poiſon ſecretly adminiſtered to him, a ſmall portion of bread was the only food which he thought proper to take.

Coſmo lived in this manner four days; and, ſhut up from all his kindred and friends, he ſoon expected to be numbered with the dead; but here, as it ſometimes happens, he found relief where leaſt expected, from the man who had been engaged to take him off. Malavolta, the keeper of the priſon, either from compunction, diſſatiſfaction, or the youth and misfortunes of the illuſtrious ſufferer, relented; and inſtead of purſuing any criminal intentions againſt the life of Coſmo, after upbraiding him with entertaining ſo unworthy an opinion of him, declared that his fears were entirely groundleſs. To convince him of this, he ſat down, and partook of every thing the priſoner choſe to eat of. The expreſſions of gratitude, together with his moſt engaging manners, and great promiſes, entirely won Malavolta, who, to ingratiate himſelf ſtill farther in the good opinion of Coſmo, invited Fargaccio, the moſt celebrated wit in Florence, to dine with him the next day, from the idea that his ſprightly mirth would contribute to lighten his misfortunes.

In the mean time, his brother Lorenzo, and his couſin Averardo, having raiſed a conſiderable body of men in Romagna and other neighbouring diſtricts, and being joined by the commander of the troops of the republic, approached towards Florence to his relief. The apprehenſion, however, that the life of Coſmo might be endangered, if they ſhould proceed to open violence, induced them to abandon their enterpriſe. At length Rinaldo and his adherents obtained a decree of the magiſtracy, by which Coſmo was baniſhed to Padua for ten years, his brother to Venice for five years; and ſeveral of their relations and adherents ſhared the ſame fate.

Coſmo received this determination of his judges with a compoſure that gained him the compaſſion and the admiration of many of his moſt inveterate enemies. He would gladly have left the city purſuant to his ſentence; but he was detained by his enemies till their authority ſhould be eſtabliſhed: and it was not till he thought of bribing the gonfalonier, and another creature of Rinaldo's, that he was privately taken from his confinement, and conducted out of Florence.

Padua, to which he was confined by his ſentence, was in the dominions of Venice; but before he could reach that place, he received a deputation from the ſenate, the purport of which was to condole with him for his misfortunes, and to promiſe him their protection and aſſiſtance in whatever he ſhould deſire. He experienced the treatment of a prince rather than that of an exile. Nor were that wiſe people without good reaſons for ſuch a conduct. Venice had long regarded Florence as her rival in commerce, and hoped, by conferring upon Coſmo the moſt flattering diſtinctions, to prevail upon him to reſide there in future; prudently ſuppoſing, that the manufactories of Florence, and the great commerce the Medici had carried on throughout Italy, and extended far beyond it to the wealthieſt kingdoms in Europe, would become their own by enrolling him amongſt their ſubjects.

The readineſs with which Coſmo had given way to the temporary clamour raiſed againſt him, and the reluctance which he had ſhewn to renew thoſe rencounters which had ſo often deluged the ſtreets of Florence with blood, gained him new friends, even during his exile. The utmoſt exertions of his antagoniſts could not long prevent the choice of ſuch magiſtrates as were known to be attached to the cauſe of the Medici; and no ſooner did they enter on their office, than Coſmo and his brother were recalled, and Rinaldo with his adherents were compelled to quit the city. This event took place about a year after the baniſhment of Coſmo.

The ſubſequent conduct of this great man (for great all allow him to have been) has been painted in different colours by different writers. Mr Noble, after Machiavel, compares his cruelties to his fallen foes with thoſe of Sylla and Octavius to the partizans of Marius and Brutus; whilſt Roſcoe repreſents his conduct as in a high degree amiable and generous. It appears to us evident, from his own words, that he had exerciſed ſome cruelties on his exiled enemies; for when one of them wrote to him, that "the hen was hatching," he replied, "She will have but a bad time of it, ſo far from her neſt." When ſome other exiles acquainted him that "they were not aſleep," he anſwered, "he could eaſily believe that, for he thought he had ſpoiled their ſleeping." At another time, ſome of the citizens remonſtrated with him upon the odiouſneſs of his conduct in baniſhing ſo many perſons; telling him, "the republic would be extremely weakened, and God offended, by the expulſion of ſo many good and pious men as he was ſending into baniſhment." His anſwer was, "It would be better for the republic to be weakened than utterly ruined; that two or three yards of fine cloth made many a one look like a good man; but that ſtates were not to be governed or maintained by counting a ſtring of beads, and mumbling over a few *Pater noſters*."

From this time the life of Coſmo de Medici was an almoſt uninterrupted ſeries of proſperity. His misfortunes had taught him, that the affectation of grandeur is more dangerous in a free ſtate than uſurpation. He adopted, therefore, the dreſs, behaviour, and manners, of a private citizen. His clothes were of the ſame faſhion and materials as the reſt of the Florentines. In the ſtreets he walked alone and unguarded. His table was ſupplied from what his eſtate of Mugello produced, nor had he one ſervant more than was abſolutely neceſſary; thus endeavouring to unite the character of a prince with that of a merchant, and a private perſon in a republic.

Whilſt he rejected all offices in the magiſtracy, no buſineſs was tranſacted without its being firſt ſettled at Mugello: nor did he contract any alliances but with the ſons and daughters of the citizens of Florence; yet all foreign princes and courts paid his children the reſpect due only to thoſe of ſovereigns; and the family of Coſmo received educations equal to thoſe of the greateſt potentates.

A proper judgment may be formed of his immenſe traffic, and the prodigious advantages accruing from it: For though a private citizen of Florence only, yet he poſſeſſed at one time more money than what was in all the treaſuries of the different ſovereigns in Europe. When Alfonſo king of Naples leagued with the Venetians againſt Florence, Coſmo called in ſuch immenſe debts from thoſe places, as deprived them of reſources for carrying on the war. During the conteſt between the houſes of York and Lancaſter, he furniſhed Edward IV. with a ſum of money ſo great, that it might almoſt be conſidered as the means of ſupporting that monarch on the throne.

In his public and private charities, in the number and grandeur of the edifices he erected, not only in Florence, but in the moſt diſtant parts of the world, and in the foundations which he endowed, he ſeemed to more than vie with majeſty. He ſupplied moſt of the exigencies of the ſtate from his private purſe; and there were few citizens that had not experienced his liberality, and many without the leaſt application, particularly the nobles.

But in nothing did his munificence produce ſo much good to the world, or acquire ſuch honour to himſelf, as when it was exerted for the promotion of ſcience, and the encouragement of learned men; and upon nothing did Coſmo delight ſo much to exert it. The ſtudy of the Greek language had been introduced into Italy towards the latter part of the preceding century; but it had again fallen into neglect. After a ſhort interval, an attempt was made to revive it, by the intervention of Emanuel Chryſoloras, a noble Greek, who taught that language at Florence, and other cities of Italy, about the beginning of the 15th century. His diſciples, who were numerous and reſpectable, kept the flame alive till it received new aid from other learned Greeks, who were driven from Conſtantinople by the dread of the Turks, or by the total overthrow of the Eaſtern Empire. To theſe illuſtrious foreigners, as well as to the learned Italians, who ſhortly became their ſucceſsful rivals, even in the knowledge of their national hiſtory and language, Coſmo afforded the moſt liberal ſupport and protection. The very titles of the works of ancient authors, which were brought to light by his munificence, would extend this article beyond its proper limits. Such, indeed, was the eſtimation in which theſe works were then held in Italy, that a manuſcript of the hiſtory of Livy, ſent by Coſmo de Medici to Alfonſo king of Naples, with whom he was at variance, conciliated the breach between them.

As the natural diſpoſition of Coſmo led him to take an active part in collecting the remains of the ancient Greek and Roman writers, ſo he was enabled by his wealth, and by his extenſive mercantile intercourſe with different parts of Europe and of Aſia, to gratify a paſſion of this kind beyond any other individual. To this end he laid injunctions on all his friends and correſpondents, as well as on the miſſionaries and preachers who travelled into the remoteſt countries, to ſearch for and procure ancient manuſcripts, in every language, and on every ſubject. The ſituation of the Eaſtern Empire, then falling into ruins, afforded him an opportunity of obtaining many ineſtimable works in the Hebrew, Greek, Chaldaic, Arabic, and other eaſtern languages. From theſe beginnings aroſe the celebrated library of the Medici; which, after various viciſſitudes of fortune, and frequent and conſiderable additions, has been preſerved to the preſent times under the name of the *Bibliotheca Mediceo Laurentiana.*

Nor was Coſmo a mere collector of books, he was himſelf, even in old age, a laborious ſtudent. Having been ſtruck with the ſublime ſpeculations of Plato, which he had heard detailed in lectures by a Greek monk, who had come from Conſtantinople to the council of Florence, he determined to found an academy for the cultivation of that philoſophy. For this purpoſe he ſelected Marſilio Ficino, the ſon of his favourite phyſician, and deſtined him, though very young, to be the ſupport of his future eſtabliſhment. The education of Ficino was entirely directed to the Platonic philoſophy; nor were the expectations which Coſmo had formed of him diſappointed. The Florentine academy was ſome years afterwards eſtabliſhed with great credit, and was the firſt inſtitution in Europe for the purſuit of ſcience, detached from the ſcholaſtic method then univerſally adopted. It is true, the fanciful doctrines of Plato are as remote from the purpoſes of life as the ſubtleties of Ariſtotle; but, by dividing the attention of the learned between them, the dogmas of the Stagyrite were deprived of that ſervile reſpect which had ſo long been paid to them, and men learned by degrees to think for themſelves.

The foſtering hand of Coſmo was held out to art as well as to ſcience; and architecture, ſculpture, and painting, all flouriſhed under his powerful protection. The countenance ſhewn by him to theſe arts was not ſuch as their profeſſors generally receive from the great. It was not conceded as a bounty, nor received as a favour, but appeared in the friendſhip and equality that ſubſiſted between the artiſt and his patron; and the ſums of money, which Coſmo expended on pictures, ſtatues, and public buildings, appear almoſt incredible.

Coſmo now approached the period of his mortal exiſtence; but the faculties of his mind remained unimpaired. About twenty days before he died, he ſent for Ficino, and enjoined him to tranſlate from the Greek the treatiſe of Xenocrates on death. Calling into his chamber his wife and his ſon Piero, he entered into a narrative of all his public tranſactions; in which he gave a full account of his extenſive mercantile connections, and adverted to the ſtate of his domeſtic concerns. To Piero he recommended a ſtrict attention to the education of his ſons; and requeſted, that his funeral might be conducted with as much privacy as poſſible. He died on the firſt of Auguſt 1464, at the age of 75 years, deeply lamented by a great majority of the citizens of Florence. Their eſteem and gratitude had indeed been fully ſhewn ſome time before, when, by a public decree, he was honoured with the title of *Pater Patriæ*, an appellation which was inſcribed on his tomb; and which, as it was founded, ſays Roſcoe, on real merit, has ever ſince been attached to the name of Coſmo de Medici.

Medici (Lorenzo de), juſtly ſtyled the *magnificent*, was the grandſon of Coſmo, and about 16 years of age when his grandfather died. His father Piero de Medici, though poſſeſſed of more than ordinary talents, as well as of a very conſiderable ſhare of worth, was, from various circumſtances, little qualified to maintain the influence which his family had gained in the republic of Florence. From very early life he had been tortured by the gout; and almoſt uninterrupted pain had made him peeviſh. Such a diſpoſition was not calculated to retain the affections of the giddy Florentines, or to perſuade republicans that they were free, while they ſubmitted to the government of a ſingle individual. All this Coſmo had foreſeen, and had done what wiſdom could do to preſerve to his family that aſcendency in the republic which he had himſelf acquired. He exhorted Piero to beſtow the utmoſt care on the education of his ſons, of whoſe capacity he expreſſed a high opinion; he recommended to him Diotiſalvo Neroni, a man whom he had himſelf raiſed from obſcurity to an eminent rank, as a counſellor, in whoſe wiſdom and fidelity he might place the utmoſt confidence: and to bind the inhabitants of Florence to the houſe of Medici by the ſtrongeſt of all ties, he had diſtributed among them, under the denomination of loans, immenſe ſums, which he knew they would not ſoon be able to repay.

Piero paid the utmoſt deference to the dying injunctions of his father. He had himſelf an ardent love of letters; and under the eye of the venerable Coſmo, he had given his two ſons, Lorenzo and Juliano, the beſt poſſible domeſtic education. In the Greek language, in ethics, and in the principles of the Ariſtotelian philoſophy, Lorenzo, the eldeſt, had the advantage of the precepts of the learned Argyropylus (a), and in thoſe of the Platonic ſect he was ſedulouſly inſtructed by Marſilio Ficino (ſee Ficinus, *Encycl.*); but for his moſt valuable accompliſhments he was not indebted to any preceptor. To complete his education, however, it was judged expedient that he ſhould viſit ſome of the principal courts of Italy; and very ſoon after the death of his grandfather, he repaired to Rome, Bologna, Ferrara, Venice, and Milan, where he gained the eſteem of all whoſe eſteem was of value.

(a) This man had fled from Conſtantinople, when it was taken by the Turks, to Florence, where he was protected by Coſmo de Medici.

Thus attentive was Piero to the advice of his father with reſpect to the education of his eldeſt ſon; nor was he leſs attentive to it in the choice of his principal counſellor. He intruſted the whole of his affairs into the hands of Neroni, and gave him Coſmo's accounts to peruſe and ſettle. That ambition, which perhaps had lain lurking in this man's mind, was now called forth, and he baſely formed the ſcheme of ruining the ſon of his patron, by building upon his misfortunes his own future grandeur. For this purpoſe, he lamented the abſolute neceſſity there was for an immediate call upon thoſe who were indebted to Piero as Coſmo's repreſentative; telling him, that a delay might ſubject him to the greateſt inconveniences. Piero conſented, though with reluctance, to his ſuppoſed friend's advice. The reſult was ſuch as Neroni expected. Thoſe who were friends of the father became enemies of the ſon; and had not Piero diſcovered the ſnare, and deſiſted from ſuch rigorous proceedings, he might have found, when too late, that in ſupporting the character of the merchant, he had forgotten that of the ſtateſman; for all the citizens of Florence were his debtors.

Soon after this, an attempt was made to aſſaſſinate Piero, by a powerful party which had always been inimical to the houſe of Medici; but it was defeated by Lorenzo, who diſplayed on that occaſion a ſagacity and promptitude of mind which would have done honour to the oldeſt ſtateſman. A few of the conſpirators were declared enemies to the ſtate, and condemned to baniſhment; but by far the greater part of them were pardoned on the ſolicitation of Lorenzo, who declared, that "he only knows how to conquer, who knows how to forgive."

In the year 1469 Piero de Medici died; and Lorenzo ſucceeded to his authority as if it had been a part of his patrimony, being requeſted by the principal inhabitants of Florence, that he would take upon himſelf the adminiſtration of the republic in the ſame manner that his grandfather and father had done.

In the month of December 1470, a league was ſolemnly concluded between the pope, the king of Naples, the duke of Milan, and the Florentines, againſt Mahomet II. who had vowed not to lay down his arms till he had aboliſhed the religion of Chriſt, and extirpated all his followers. The pope, however (Paul II.), died on the 26th of July 1471; and Sixtus IV. ſucceeding to the chair of St Peter, Lorenzo was deputed from Florence to congratulate him on his elevation. Two more oppoſite characters can hardly be conceived than thoſe of Sixtus and Lorenzo. The former was cruel, treacherous, and ſordid; the latter was merciful, candid, and generous. Yet ſuch inſtances of mutual good will took place between them on this occaſion, that Lorenzo, who, under the direction of his agents, had a bank eſtabliſhed at Rome, was formally inveſted with the office of treaſurer of the Holy See.

Piſa had been under the dominion of Florence from the year 1406, and it had acquired ſome celebrity on account of its academy, which had exiſted almoſt two centuries. That academy, however, had fallen into decay; and, in the year 1472, the Florentines reſolved to reſtore it to its priſtine ſplendour. Five citizens, of whom Lorenzo de Medici was one, were appointed to ſuperintend the execution of their purpoſe; but Lorenzo, who was the projector of the plan, undertook the chief management of it; and, in addition to 6000 florins annually granted by the ſtate, expended, in effecting his purpoſe, a large ſum of money from his private fortune. In doing this, he only imitated the example of his father and grandfather; for in the courſe of 37 years, reckoning from the return of Coſmo from baniſhment, this illuſtrious family had expended on works of charity or public utility upwards of 660,000 florins. "Some perſons (ſaid Lorenzo) would perhaps be better pleaſed to have a part of it in their purſe; but I conceive that it has been of great advantage to the public, and well laid out, and am therefore perfectly ſatisfied."

In the year 1474, Lorenzo incurred the diſpleaſure of the pope for oppoſing ſome of his encroachments on the petty princes of Italy; and the revenge planned by Sixtus was of ſuch a nature as would have diſgraced, we do not ſay a Chriſtian biſhop, but the rudeſt ſavage. He began by depriving Lorenzo of the office of treaſurer of the Roman See, which he gave to the Pazzi, a Florentine family, who, as well as the Medici, had a public bank at Rome. By this ſtep he ſecured the intereſt of the Pazzi, who, it is probable, were to govern Florence under the pope, when Lorenzo and Juliano de Medici ſhould be cut off, and their friends and adherents driven from the republic. The principal agent engaged in the undertaking was Franſeſco Salviati archbiſhop of Piſa, to which rank he had lately been promoted by Sixtus, in oppoſition to the wiſhes of the Medici. The other conſpirators were Giacopo Salviati, brother to the archbiſhop; Giacopo Poggio, one of the ſons of the celebrated Poggio Bracciolini (ſee POGGIUS, *Encycl.*); Barnardo Bandini, a daring libertine, rendered deſperate by the conſequence of his exceſſes; Giovanni Battiſti Monteficco, who had diſtinguiſhed himſelf as general of the pope's armies; Antonio Maffei, a prieſt of Volterra; and Stephano de Bagnona, one of the apoſtolic ſcribes; with ſeveral others of inferior note. The cardinal Riario, then at Piſa, was likewiſe an inſtrument in the conſpiracy; but he can hardly be conſidered as an agent, for he was kept ignorant of what was going on, and enjoined only to obey whatever directions he might receive from the archbiſhop of Piſa.

The aſſaſſination of the illuſtrious youths was fixed for Sunday, April 26. 1478; the place the cathedral of Florence, at the moment the hoſt was to be elevated; and their murder was to be the ſignal for ſeizing and expelling from the walls of the city all their relations and friends. What a tranſaction this for one who preſumed to ſtyle himſelf the vicar of Chriſt, the common father of Chriſtendom, to patronize!

The fatal day arrived, and Lorenzo was already in the church; but Juliano remained at home, occaſioned by a ſlight indiſpoſition. The conſpirators, determining not to loſe one of their victims, went to invite, to intreat him, to go. They embraced (B), and led him, by a tender violence, to the cathedral. The ſignal was

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(B) The aſſaſſins embraced Juliano, to diſcover whether he wore any ſecret armour, that they might know where to ſtrike with the ſureſt aim.

Medici.

given by the elevation of the conſecrated wafer; and whilſt the people fell upon their knees to adore, the aſſaſſins roſe, and, as was concerted, two of them, Franciſco Pazzi and Barnardo Bandini, fell upon Juliano. The latter directed his poignard ſo truly, that it entered into the boſom of the unoffending youth, and he fell mortally wounded at his feet.

In a moment, as muſt be ſuppoſed, all was confuſion. Lorenzo, alarmed, put himſelf in a poſture of defence, when, in an inſtant, Antonio of Volterra, and Stephano a prieſt, the dependant of the archbiſhop, who, upon Giovanni Battiſti's declining the infamous taſk, undertook his deſtruction, ruſhed upon him as their deſtined prey. The conteſt continued ſome time. Lorenzo had received a wound in his neck, and ſeemed to contend for his life in vain; but a ſervant, whom he had lately relieved from priſon, inſpired by gratitude, heroically threw himſelf between his beloved lord and his aſſaſſins, receiving in his body thoſe weapons that were aimed at the breaſt of Lorenzo. This fidelity ſaved him; for by one vigorous effort he broke from Antonio and Stephano, and with a few friends ruſhed into the ſacriſty, ſhutting the doors behind them, which were of braſs. Apprehenſions being entertained, that the weapon which had wounded him was poiſoned, a young man ſucked the wound, endangering his own life to ſave that of Lorenzo.

The rage of the people to ſee one of their favourites expiring, and the other covered with blood, was inexpreſſible. The cardinal Riario found it difficult to ſave his life at that altar which he had ſtained by ſo horrid a deed, and to which he then fled for protection.

Whilſt this infamous ſcene was acting in the cathedral, others of the conſpirators were attempting to ſeize the Palazzo; but with no better ſucceſs. The archbiſhop Salviatti, who had undertaken to head them, gave the magiſtrates ſuſpicion by thoſe violent emotions which agitated his whole frame. The nine ſenators who compoſed the magiſtracy, including the gonfalonier, who had been appointed by, and were, in other words, the privy council of the Medici, immediately attacked thoſe who intended to have ſurpriſed them; and Salviatti and his followers had no ſooner gained the ſecond floor, than they found themſelves priſoners.

Jacobo Pazzi ſoon appeared in the ſtreet, proclaiming, with exultation, the murder of Juliano; and inviting the Florentines to free themſelves from the Medicean ſlavery; but perceiving that he was not joined by the people, the magiſtrates ſent off 100 horſe to the reſcue of Lorenzo. This was the more to be commended, becauſe they continued to be aſſaulted by the conſpirators, who, finding their ſituation deſperate, forced themſelves to the ground floor, determining, if poſſible, to ſeize the Palazzo. The magiſtrates, with their attendants, acted with ſuch reſolution and valour, that as often as they gained an entrance, they drove them back, killing ſome of the aſſailants upon the ſpot, others they threw out of the windows upon the pavement; and to ſtrike an awe into thoſe that were without, they had the boldneſs and virtue to hang the archbiſhop from one of the windows, dreſſed as he was in his pontifical robes, with Poggio, another of the chief conſpirators. Florence reſounded in every part with the exclamation—Medici, Medici! down with their enemies!

Lorenzo was liberated from that part of the cathedral to which he had fled, and conveyed home in triumph, where his wounds were attended to, and where he found himſelf ſurrounded by his moſt valuable friends, to whom he was endeared by the ſhocking occurrences of the day. His partizans, however, did not ſpend their time only in lamentations for the death of one of the brothers, and exultations for the preſervation of the other; they united in purſuing the conſpirators, ſparing none that fell into their hands. Jacobo Pazzi was taken flying with his forces into Romania, and immediately hung. An officer of the pope's, who commanded a brigade under count Hirronimo, had alone the favour of decapitation. Bandini fled privately to Piſa, thence to Naples, and, laſtly, to Conſtantinople; but Mahomet, to oblige Lorenzo, ſeized, and ſent him back; and he was hung out of the ſame window from which the archbiſhop had ſuffered. An embaſſy was ſent from Florence to thank the ſultan in the name of the republic.

Throughout the whole of this juſt but dreadful retribution, Lorenzo had exerted all his influence to reſtrain the indignation of the populace. He entreated that they would reſign to the magiſtrates the taſk of aſcertaining and of puniſhing the guilty, leſt the innocent ſhould be incautiouſly involved in deſtruction; and his appearance and admonitions had an inſtantaneous effect. By his moderation, and even kindneſs to the relatives of the conſpirators, he ſought to obliterate the remembrance of paſt diſturbances; and by his interference, even the ſurvivors of the Pazzi were reſtored to their honours, of which they had been deprived by a decree of the ſtate.

The generoſity and moderation of Lorenzo had no effect on the temper of Sixtus, who ſolemnly excommunicated him, the gonfalonier, the magiſtrates, and their immediate ſucceſſors; and in the bull which he iſſued on this occaſion, he ſtyles Lorenzo de Medici "the child of iniquity, and the nurſling of perdition!" Not content with this ebullition of reſentment, he ſuſpended the biſhops and clergy of the Florentine territories from the exerciſe of their ſpiritual functions; thus laying the whole republic under an interdict. This had been a formidable weapon in the hands of his predeceſſors, who had, by means of it, overawed the moſt powerful monarchs; but the general character of Sixtus was ſo infamous, and his preſent injuſtice ſo manifeſt, that by the exertions of the biſhop of Arezzo, a convocation was held in the cathedral church of Florence, in which Sixtus was accuſed of *fornication* and *adultery*, with other infamous vices; declared to be the principal inſtigator of the conſpiracy againſt the Medici; and the ſentence of excommunication which he had fulminated againſt Lorenzo and the Florentine magiſtrates was called in direct terms, the "execrable malediction of a damned judge (*maledictam maledictionem damnatiſſimi judicis*)!

How ſuch language could be reconciled to the notions which then prevailed of the ſanctity of the pope, and the plenitude of his power, it is needleſs to inquire; but the reader will not be ſurpriſed that the prelates, who made uſe of it, paid no regard to the interdict of Sixtus. The pontiff, however, did not relax from his purpoſe. Whilſt he brandiſhed with one hand the ſpiritual weapon, which the Florentines treated with ſuch contempt, in the other, he graſped a temporal ſword, which he now openly, as he had before ſecretly, aimed at the breaſt of Lorenzo. At his inſtigation the king of Naples diſpatched an envoy to Florence, to require the citizens to baniſh Lorenzo from the Tuſcan territories, if they would not incur the vengeance both of him and of the pope. Theſe threats produced not the intended effect; for the Florentines avowed their firm reſolution to ſuffer every extremity, rather than betray the man whom they conſidered as guardian of the republic. War therefore was commenced; and the republic was on the point of being ruined, when Lorenzo taking advantage of a truce, threw himſelf, with a reſolution not to be equalled, into the hands of the king of Naples. He judged, perhaps, that any ſtipulations for his perſonal ſafety would be uſeleſs with a prince who had ſported with honour, juſtice, mercy, and the moſt ſolemn treaties. But, whilſt all viewed him as a victim who had devoted himſelf to ſave his country, he, by perſuaſive eloquence, obtained of this crafty perfidious monarch a ſeparate peace, and returned to Florence crowned with a ſucceſs that no one thought poſſible, and where he was received as its tutelar deity. The pope, however, continued inflexible, till a deſcent of the Turks upon Italy reſtored him to his ſenſes, and made him willing to receive the ſubmiſſion of Florence, and reconcile its inhabitants to the church.

Soon after the termination of the hoſtilities between Sixtus and the republic of Florence, Lorenzo began to unfold plans for ſecuring the peace of Italy, which confer the higheſt honour on his political life. To counterpoiſe all the jarring intereſts of the petty ſtates of which that country was compoſed, to reſtrain the powerful, ſuccour the weak, and to unite the whole in one firm body which might be able, on the one hand, ſucceſsfully to oppoſe the formidable power of the Turks, and, on the other, to repel the incurſions of the French and Germans, were the important ends which this great man propoſed to accompliſh. But before he engaged in theſe momentous undertakings, he had further perſonal dangers to encounter. By the inſtigation of Cardinal Riario, and ſome Florentine exiles, one Battiſta Fraſcobaldi, with only two aſſiſtants, undertook to aſſaſſinate him in the church of the Carmeli, on the feſtival of the aſcenſion 1481; but the plot was diſcovered, the conſpirators executed, and Lorenzo henceforth ſeldom went abroad without being ſurrounded by a number of tried friends.

Lorenzo was now at liberty to proſecute his benevolent purpoſes; and after contributing to the expulſion of the Turks from Italy, he ſet himſelf in good earneſt to ſupport the weak ſtates againſt the encroachments of the more powerful. This neceſſarily embroiled the republic at one time with the pope, at another with the king of Naples; now with the Venetians, and then with the Duke of Milan: but when ſome exclaimed againſt him as being too precipitate in involving the republic in dangerous and expenſive wars, he explained to them the neceſſity of maintaining the balance of power, if they would preſerve the independence of their own ſtate; and ſo completely had he made himſelf maſter of this ſubject, that he convinced the moſt incredulous of the propriety of his meaſures, which, in 1488, introduced general tranquillity into Italy.

At this period, the city of Florence was at its higheſt degree of proſperity. The vigilance of Lorenzo had ſecured it from all apprehenſions of external attack; and his acknowledged diſintereſtedneſs and moderation had almoſt extinguiſhed that ſpirit of internal diſſenſion for which it had been ſo long remarkable. The Florentines gloried in their illuſtrious citizen, and were gratified by numbering in their body a man who wielded in his hands the fate of nations, and attracted the reſpect and admiration of all Europe.

Yet amidſt public affairs ſo intricate and ſo momentous, ſuch was the capacity of this man's mind, and ſuch his verſatility of genius, that, for the greater part of his life, he carried on a commerce as extenſive as that of his grandfather, whilſt he afforded ſtill greater encouragement to learning and learned men. Coſmo had greatly promoted the ſtudy of the ancient languages and ancient philoſophy. Lorenzo did the ſame thing: but he did much more; he encouraged the cultivation of his own tongue, which had been neglected ſince the age of Petrarca; and by ſetting a great example himſelf, he produced a race of Italian poets, which have hardly been ſurpaſſed in any age or nation. To enumerate even the names of the elegant ſcholars whom he patroniſed, would extend this article far beyond its limits. In the academy of Piſa, of which mention has been already made, the ſtudies were chiefly confined to the Latin language, and to thoſe ſciences of which it was the principal vehicle. At Florence the Greek tongue was taught under the ſanction of a public inſtitution, either by native Greeks or learned Italians, whoſe ſervices were procured by the diligence of Lorenzo de Medici, and repaid by his bounty. He placed Michael Angelo at the head of an academy, which he erected for painting and ſculpture, furniſhing it with the beſt models of antiquity. He built and endowed a public library, and ſent Laſcaris, of imperial deſcent, to Conſtantinople more than once, to procure Greek manuſcripts. For father Moriano, the orator, a monaſtery was built; and Florence owed many of her fineſt edifices to him. Politiano and Ficino were among his moſt intimate friends; and it is not perhaps too much to ſay, that he did more for letters and ſcience and art than any other individual that ever exiſted. His own acquirements in learning were great; and his poetry, of which the reader will find many ſpecimens in the elegant work of Roſcoe, was exquiſite.

Is it ſurpriſing, when we examine Lorenzo's character, that all Italy, all Chriſtendom, even the Mahometans, gave him the moſt flattering marks of approbation, and ſtrove who ſhould oblige him moſt, by preſenting him with whatever was rare and valuable? His palace was conſtantly filled with men famous in every elegant, every uſeful ſcience, and the neighbouring princes flocked to it as to the temple of wiſdom. The celebrated prince of Mirandola, on his account, choſe Florence for his reſidence, and died there.

To a moſt engaging perſon was added each grace, and every accompliſhment. He was the favourite of the ladies, the envy of the men, and the admiration of both. The ſtateſman of his time; unrivalled in chivalry; one of the moſt eminent orators that the world has produced. His poetic merit, with his judgment in, and patronage of that art, procured him the title of "Father of the Muſes." In liberality to his fellow-citizens, as well as in every other reſpect, except as a general, he exceeded even Cæſar himſelf; and had not peace been his dear delight, his talents would have made him a conſummate commander. Yet with all theſe ſuperior accompliſhments, he did not think it beneath him to indulge in amuſements which perſons, leſs wiſe, would have thought an impeachment of their underſtanding, and he would often ſeek pleaſure in his nurſery, ſpending hours there in all the frivolous pranks of childiſh diverſion. In fine, "the gravity of his life, if compared with its levity, muſt make him appear as a compoſition of two different perſons, incompatible, and, as it were, impoſſible to be joined with the other."

Lorenzo, like moſt other great men, had wiſhed to ſpend his laſt years in the tranquillity of retirement. He therefore at an early period wound up his mercantile concerns, and divided his time between the cares of the republic at Florence, and the cultivation of his eſtates in the country. He wiſhed even to diveſt himſelf of all public concerns, and get his ſecond ſon Giovanni admitted into holy orders at the age of ſeven years, that he might be fit for eccleſiaſtical preferment before he ſhould be deprived of the protection of his father. The young eccleſiaſtic, who afterwards made ſuch a figure as Leo X. was accordingly appointed by Louis XI. of France, abbot of Fonte-Dolac, before he was eight years of age; and by Innocent VIII. a cardinal, when he was little more than thirteen. This added much to the influence of the family, not only in the Tuſcan ſtates, but through all Italy; and Lorenzo having introduced his eldeſt ſon into public life, and accompliſhed a marriage between him and the daughter of a noble family at Rome, thought he might commit the affairs of the republic in a great meaſure to Piero, and indulge his own taſte in the converſation of his learned friends. This dream of felicity however was not realized. Early in the year 1492, he was attacked by a diſeaſe, under which he had long laboured, with ſuch violence, that on the 8th of April he died in the midſt of his weeping friends, after having taken of them, one by one, an affectionate farewel, and given to his ſon Piero much ſalutary counſel, which he thought not fit to follow.

The character of this great and good man is developed in the detail which we have given of his conduct through life: But it may not be improper to add, that ſuch was the love and veneration of the citizens to him, that the phyſician, who had attended him on his death-bed, afraid to return to Florence, left the houſe in a ſtate of diſtraction, and plunged himſelf into a well. Throughout the reſt of Italy the death of Lorenzo was regarded as a public calamity of the moſt alarming kind. Of the arch which ſupported the political fabric of that country he had long been conſidered as the centre, and his loſs ſeemed to threaten the whole with immediate deſtruction. When Ferdinand king of Naples was informed of the event, he exclaimed, "This man has lived long enough for his own glory, but too ſhort a time for Italy."

MEDICINA FORENSIS, is a phraſe uſed in Germany to denote thoſe parts of anatomical and phyſiological knowledge, which enable phyſicians and ſurgeons to decide certain cauſes as judges in courts of juſtice. In that country it has long been law and cuſtom (if we miſtake not, by the Caroline code of Charles V.) to refer caſes of *poiſoning*, *child murder*, *rape*, *pregnancy*, *impotency*, *ideotiſm*, &c. to the medical faculty, which, in the univerſities and ſome other great towns, is conſtituted into a kind of court for the trial of ſuch queſtions. In this country there are no ſuch courts; but in criminal trials medical gentlemen are often called upon to deſcribe the ſymptoms of *poiſoning*, *child-murder*, *rape*, &c. and therefore it becomes them to obtain an accurate knowledge of theſe ſymptoms, and to ſtore their memories with a number of minute facts, to which they may have occaſion to appeal when giving their evidence.

The importance of this ſubject induced the profeſſor of the inſtitutes of phyſic in the univerſity of Edinburgh to reſolve lately to read an annual courſe of lectures on MEDICAL JURISPRUDENCE. This, we doubt not, will prove a valuable courſe; for though it is hardly conceivable that, under the head *medical juriſprudence*, any *knowledge* can be communicated which a well educated phyſician would not neceſſarily have acquired, without attending ſuch a courſe; yet it is very obvious, that the recollection of the young phyſician may receive great aid from his liſtening to the well arranged lectures of an accurate profeſſor. From theſe lectures he may ſtore his mind with a collection of aphoriſms which ſhall be always ready on the day of examination; or the lectures themſelves may be delivered in queſtions and anſwers with all the formalities of a criminal court.

We have heard it obſerved, that to attend a courſe of ſuch lectures would be of the utmoſt advantage to all who may be called upon to ſerve as jurymen in criminal trials; but of the truth of this obſervation we are more than doubtful. Perſons who are only *half* inſtructed are always conceited of their own attainments; and men not acquainted with anatomy and phyſiology cannot be *more* than half inſtructed by the ableſt courſe poſſible to be given of medical juriſprudence. Such perſons indeed can hardly avoid miſtaking the ſenſe of the profeſſor's language, however perſpicuous that language may be. Of this we had lately a very ſtriking inſtance. A gentleman, by no means illiterate, though a ſtranger to anatomical and phyſiological ſcience, was expatiating to the writer of this article upon the general importance of medical juriſprudence, a courſe of which, he ſaid, he had attended for the ſole purpoſe of qualifying himſelf for diſcharging the important duties of a juryman. Upon being aſked what he had learned? he replied, that he had been taught, among other things which we thought frivolous, to diſcern, from the ſymptoms of *hanging*, whether the dead man had been hanged by *himſelf* or by *another*. We need not ſurely obſerve, that no ſuch leſſon was ever taught in any univerſity, or by any medical lecturer; but it is worthy of conſideration, whether lectures on medical juriſprudence may not have the moſt pernicious effects on the minds of men ſo little qualified as this gentleman to profit by them. To the regularly educated phyſician and ſurgeon ſuch lectures may prove uſeful; to the plain citizen, not ſkilled in anatomy and phyſiology, they muſt prove dangerous; as their only tendency is to make him deſpiſe the evidence given before him by the regular phyſician or ſurgeon; to place implicit confidence in his own ſuperficial knowledge; and thus to decide at random on the life or death of his fellow-creature:

A little learning is a dangerous thing;
Drink deep, or taſte not the Pierian ſpring.

MEDINA, the capital of the kingdom of Woolli in Africa, is ſituated in 13° 40′ N. Lat. and 12° 40′ W. Long. It is a place of conſiderable extent, and may contain from 800 to 1000 houſes. It is fortified in the common African manner, by a ſurrounding high wall built of clay, and an outward fence of pointed ſtakes and prickly buſhes; but the walls are neglected, and the outward fence has ſuffered conſiderably from the active hands of buſy houſewives, who pluck up the ſtakes for firewood. Mr Park paſſed through it on his route eaſtward, and was treated with much kindneſs both by the king and the people. The good old ſovereign warned him of the dangers he was about to encounter, and endeavoured to perſuade him to relinquiſh all thoughts of his journey eaſtward; but when he could not prevail, he gave him a guide, who conducted him in ſafety to Koojar, the frontier town of the kingdom towards Bondou, from which it is ſeparated by an intervening wilderneſs of two days journey. Here our author was preſented, by way of refreſhment, with a liquor which taſted ſo much like the ſtrong beer of his native country (and very good beer too), as to induce him to inquire into its compoſition; and he learned, with ſome degree of ſurpriſe, that it was actually made from corn which had been previouſly malted, much in the ſame manner as barley is malted in Great Britain: a root yielding a grateful bitter was uſed in lieu of hops, the name of which he forgot; but the corn which yields the wort is the *holcus ſpicatus* of botaniſts.

Plate XXXVI.

MEDUSA. In addition to the different ſpecies of this genus of vermes deſcribed in the *Encyclopædia*, that which is repreſented in two different attitudes, fig. 1. and 2. and which ſtrongly reſembles a bagpipe in ſhape, may be worthy of notice. It is merely a white tranſparent veſicle, furniſhed with ſeveral blue tentacles yellowiſh at their extremity; its long tail, which is alſo blue, appears to be compoſed of a number of ſmall glandulous grains, flattened and united together by a gelatinous membrane. The upper part of the veſicle exhibits a kind of ſeam with alternate punctures of three different ſizes; its elongated part, which may be conſidered as the head of the animal, is terminated by a ſingle trunk, the exterior edge of which is fringed with 25 or 26 tentacles, much ſmaller than thoſe which originate from the inſertion of its long tail, and the number of which ſometimes amounts to 30. By means of theſe laſt, the diameter of which it is capable of increaſing at pleaſure by forcing in a little of the air from its body, it fixed itſelf to the ſide of the veſſel, in which it was placed, in ſuch a manner as that the extremity of ſome of its tentacles occupied a ſurface of two or three lines from its body. The moſt moveable part of the veſicle is its elongation, or the head of the animal, as it is by means of this that it performs its different motions. The rounded ſubſtance, marked by the letter P, is ſituated in the centre of the larger tentacles, which are firmly fixed to the body of the animal near its tail; and is only an aſſemblage of a few minute gelatinous globules, from the middle of which ariſe other larger globules, with a ſmall peduncle, about the middle of which is fixed a curved bluiſh coloured body, which is repreſented magnified in two poſitions at R. Martiniere, the naturaliſt, who accompanied Perouſe in his voyage round the world, met with this animal in about the 20th degree of lat. and 179° of long. eaſt from Paris.

MEGAMETER, a name ſometimes given to the MICROMETER, which ſee, *Encycl.*

MEHALL, in the language of Bengal, a place or diſtrict.

MENINSKI (Franciſcus), a moſt celebrated German orientaliſt, was born in Lorraine, then ſubject to the emperor, in the year 1623; and for copiouſneſs of learning, elegance of genius, and profound knowledge of languages, particularly thoſe of the Eaſt, proved undoubtedly one of the principal ornaments of the age in which he lived. He ſtudied at Rome under Giattino. When he was about 30, his love of letters induced him to accompany the Poliſh ambaſſador to Conſtantinople, where he ſtudied the Turkiſh language under Bobovius and Ahmed, two very ſkilful teachers. So ſucceſsful was he in this ſtudy, that when he had been there only two years, the place of firſt interpreter to the Poliſh embaſſy at the Porte was promiſed to him. When the place became vacant, he was accordingly appointed to it, and obtained ſo much credit by his conduct, that, after a time, he was ſent for into Poland, and again ſent out with full powers as ambaſſador to the Porte. For his able execution of this office, he was further honoured, by being naturalized in Poland; on which occaſion he added the Poliſh termination of *ſki* to his family name, which was Menin. Being deſirous afterwards to extend his ſphere of action, he went to the court of the emperor as interpreter of oriental languages in 1661. Here alſo, as in other inſtances, his talents and behaviour obtained the higheſt approbation; on which account he was not only ſent as interpreter to ſeveral imperial ambaſſadors at the Porte, but was intruſted in many important and confidential ſervices; and, in 1669, having paid a viſit to the holy ſepulchre at Jeruſalem, was made one of the knights of that order. After his return to Vienna he was advanced to further honours; being made one of the counſellors of war to the emperor, and firſt interpreter of oriental languages. At Vienna he died at the age of 75, in the year 1698. His great work, 1. The "Theſaurus linguarum orientalium," was publiſhed at Vienna in 1680, in 4 vols folio; to which was added, in 1687, another volume, intitled, "Complementum Theſauri linguarum orientalium, ſeu onomaſticum Latino-Turcico-Arabico-Perſicum." The former volumes having become extremely ſcarce, partly on account of the deſtruction of a great part of the impreſſion, in the ſiege of Vienna by the Turks in 1683, a deſign was formed ſome time ago in England of reprinting the work, by a ſociety of learned men, among whom was Sir William Jones. But as this undertaking, probably on account of the vaſt expence which muſt have been incurred, did not proceed, the empreſs queen Maria Thereſa, who had heard of the plan, took it upon herſelf, and with vaſt liberality furniſhed every thing neceſſary for its completion. In conſequence of this, it was begun to be ſplendidly republiſhed at Vienna in 1780, with this title: "Franciſci a Meſgnien Meninſki Lexicon Arabico-Perſico-Turcicum, adjecta ad ſingulas voces et Phraſes interpretatione Latinâ, ad uſitatiores, etiam Italicâ." Of this edition only two vols folio are yet publiſhed, extending no farther than *zal*, the ninth letter of the Arabic alphabet, which is about a third of the whole. The delay of the reſt is much to be lamented. In this edition, ſay the editors, the Lexicon of Meninſki may be ſaid to be increaſed, diminiſhed, and amended. *Increaſed*, becauſe many Arabic and Perſian words are added, from Wankuli and Ferhengi, the beſt Arabic and Perſic lexicographers whom the Eaſt has produced; and from Herbelot are inſerted the names of kingdoms, cities, aud rivers, as well as phraſes in common uſe among the Turks, &c. *Diminiſhed*, becauſe many uſeleſs ſynonyma are omitted, which rather puzzled than aſſiſted the ſtudent; as well as all the French, Poliſh, and German interpretations, the Latin being conſidered as ſufficient for all men of learning. *Amended*, with reſpect to innumerable typographical errors; which, however, from a work of this nature, no care can perhaps altogether exclude. The other works of Meninſki were occaſioned chiefly by a violent conteſt between him and a man named J. B. Podeſta, in which much acrimony was employed on both ſides. Theſe it is hardly worth while to enumerate, but they may all be ſeen in the account of his life from which this article is taken (A). It ſhould be obſerved, however, that in 1674, Podeſta publiſhed a book, intitled, "Prodromus novi linguarum orientalium collegii, juſſu Aug. &c. erigendi, in Univ. Viennenſi;" to which Meninſki oppoſed, 2. "Meninſkii Antidotum in Prodromum novi ling. orient. collegii, &c." 4to. But ſuch was the credit of his antagoniſt in the univerſity, that ſoon after there came out a decree in the name of the rector and conſiſtory, in which that antidote of Meninſki's is proſcribed and prohibited, for ſix ſpecific reaſons, as impious and infamous. Meninſki was defended againſt this formidable attack by a friend, in a ſmall tract, intitled, "Veritas defenſa, ſeu juſtitia cauſæ Dn. F. de M. M. [Meninſki] contra infame decretum Univerſitatis Viennenſis, Anno 1674, 23 Novembris, &c. ab Amico luci expoſita, Anno 1675," in which this friend expoſes, article by article, the falſehood of the decree, and exclaims ſtrongly againſt the arts of Podeſta. This tract is in the Britiſh Muſeum. Podeſta was oriental ſecretary to the emperor, and profeſſor of thoſe languages at Vienna; but is deſcribed in a very ſatirical manner by the defender of Meninſki. "Podeſta, natura Semi-Italus, ſtatura nanus, cæcutiens, balbus, imo bardus repertus, aliiſque vitiis ac ſtultitiis plenus, adeoque ad diſcendas linguas orientales inhabilis." A liſt of the works of Podeſta is, however, given by the late editors of Meninſki.

MERCHETTA, or *Marchetta Mulierum*, is commonly ſuppoſed to have been a right which, during the prevalence of the feudal ſyſtem, the lord had of paſſing the firſt night after marriage with his female villain. This opinion has been held by the greater part of our antiquarians; and we have adopted it in our hiſtory of Scotland publiſhed in the *Encyclopædia*. It appears, however, to be a miſtake. That there was a cuſtom called *merchetta mulierum*, which prevailed not only in England, Scotland, Wales, and the iſle of Guernſey, but alſo on the continent, is indeed a fact unqueſtionable; but Mr Aſtle has clearly proved, that, inſtead of being an adulterous connection, the *merchetta* was a compact between the lord and his vaſſal for the redemption of an *offence* committed by that vaſſal's *unmarried* daughter. He admits, however, that it denoted likewiſe a fine paid by a *ſokeman* or a *villain* to his lord, for a licence to marry his daughter to a free man; and that if the vaſſal gave her away without obtaining ſuch a licence, he was liable to pay a heavier fine. He quotes two authorities in ſupport of his opinion from Bracton; one of which we ſhall tranſcribe, as being alone complete evidence.

Archæologia, vol. xii.

"Ric. Burre tenet unum meſuagium et debet telliagium ſectam curiæ, et *merchet*, hoc modo, *quod ſi maritare voluerit filiam ſuam cum quodam libero homine, extra villam, faciet pacem domini pro maritagio, et ſi eam maritaverit alicui cuſtumario villæ, nihil debuit pro maritagio.*"

"The probable reaſon of the cuſtom (ſays Mr Aſtle) appears to have been this. Perſons of low rank, reſiding on an eſtate, were either *aſcripti glebæ*, or were ſubjected to ſome ſpecies of ſervitude ſimilar to the *aſcripti glebæ*. They were bound to reſide on the eſtate, and to perform ſeveral ſervices to the lord. As women neceſſarily followed the reſidence of their huſbands, the conſequence was, that when a woman of low rank married a ſtranger, the lord was deprived of part of his live ſtock; he therefore required a fine to indemnify him for the loſs of his property." Further particulars on the *merchetta* are to be found in the Appendix to vol. 1ſt of *Sir David Dalrymple's Annals of Scotland.*

MERIDIAN Line, an arch, or part of the meridian of the place, terminated each way by the horizon. Or, a meridian line is the interſection of the plane of the meridian of the place with the plane of the horizon, often called a north-and-ſouth line, becauſe its direction is from north to ſouth.

In the article Astronomy (*Encycl.*), n° 376 and 377, we have given two methods of drawing a meridian line; but it may be proper to add, in this place, the following improvement of the former of theſe from Dr Hutton's Mathematical Dictionary. "As it is not eaſy (ſays the Doctor) to determine preciſely the extremity of the ſhadow, it will be beſt to make the ſtile flat at the top, and to drill a ſmall hole through it, noting the lucid point projected by it on the ſeveral concentric circles, inſtead of marking the extremity of the ſhadow itſelf on theſe circles."

We ſhall give another method of drawing a meridian line from the ſame valuable dictionary.

Plate XXXVI.

"Knowing the ſouth quarter pretty nearly, obſerve the altitude FE of ſome ſtar on the eaſt ſide of it, and not far from the meridian HZRN: then, keeping the quadrant firm on its axis, ſo as the plummet may ſtill cut the ſame degree, direct it to the weſtern ſide of the meridian, and wait till you find the ſtar has the ſame altitude as before, as *fe*. Laſtly, biſect the angle EC*e*, formed by the interſection of the two planes in which the quadrant has been placed at the time of the two obſervations, by the right line HR, which will be the meridian ſought."

Magnetical Meridian, is a great circle paſſing thro' or by the magnetical poles; to which meridians the magnetical needle conforms itſelf. See Magnetism, *Suppl.*

MESOLABE, or Mesolabium, a mathematical inſtrument invented by the ancients, for finding two mean

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(A) We have taken this article from the Biographical Dictionary; the editors of which took it from the life of Meninſki prefixed to the new edition of his great work.

mean proportionals mechanically, which they could not perform geometrically. It conſiſts of three parallelograms, moving in a groove to certain interſections. Its figure is deſcribed by Eutocius, in his Commentary on Archimedes. See alſo Pappus, lib. 3.

MESO-Logarithm, a term uſed by Kepler to ſignify the logarithms of the coſines and cotangents.

MESURATA, a ſeaport of the kingdom of Tripoli, in Africa. A caravan proceeds from this place to Fezzan, and other interior parts toward the ſouth of Africa. It is 260 miles north of Mourzook. E. lon. 15. 5. N. lat. 31. 3.

METALLIC Tractors. See Perkinism in this *Suppl.*

METONIC Cycle, called alſo the *Golden Number*, and *Lunar Cycle*, or *Cycle of the Moon*, that which was invented by Meton the Athenian; being a period of 19 years. See Cycle, *Encycl.*

MHA Rajah, the higheſt title of Hindoos.

MICROCOUSTICS, or Microphones, inſtruments contrived to magnify ſmall ſounds, as microſcopes do ſmall objects.

MICROCOSMIC Salt. See Chemistry-*Index*, *Suppl.*

MIDDLE Latitude, is half the ſum of two given latitudes; or the arithmetical mean, or the middle between two parallels of latitude. Therefore,

If the latitudes be of the ſame name, either both north or both ſouth, add the one number to the other, and divide the ſum by 2; the quotient is the middle latitude, which is of the ſame name with the two given latitudes. But

If the latitudes be of different names, the one north and the other ſouth; ſubtract the leſs from the greater, and divide the remainder by 2, ſo ſhall the quotient be the middle latitude, of the ſame name with the greater of the two.

MIDSUMMER-Day, is held on the 24th of June, the ſame day as the nativity of St John the Baptiſt is held.

MILK, or Milkyet, property in Bengal.

MILLS of various kinds are deſcribed in the article Mechanics (*Encycl.*); and he who ſhall ſtudy that article, together with *Water-Works*, and Machinery, in this *Supplement*, will have a ſufficient knowledge of the principles upon which mills muſt be conſtructed ſo as that they may produce their proper effects. The ſubject is introduced into this place merely to put it into the power of our countrymen to adopt, if they ſhall think fit, the improvements which have been made in the machinery of flour mills in America.

The chief of theſe conſiſt in a new application of the ſcrew, and the introduction of what are called elevators, the idea of which was evidently borrowed from the chain pump. The ſcrew is made by ſticking ſmall thin pieces of board, about three inches long and two wide, into a cylinder, ſo as to form the ſpiral line. This ſcrew is placed in a horizontal poſition, and by turning on its axis it forces wheat or flour from one end of a trough to the other. For inſtance, in the trough which receives the meal immediately coming from the ſtones, a ſcrew of this kind is placed, by which the meal is forced on, to the diſtance of ſix or eight feet, perhaps, into a reſervoir; from thence, without any manual labour, it is conveyed to the very top of the mill by the elevators, which conſiſt of a number of ſmall buckets of the ſize of tea-cups, attached to a long band that goes round a wheel at the top, and another at the bottom of the mill. As the band revolves round the wheels, theſe buckets dip into the reſervoir of wheat or flour below, and take their loads up to the top, where they empty themſelves as they turn round the upper wheel. The elevators are incloſed in ſquare wooden tubes, to prevent them from catching in any thing, and alſo to prevent duſt. By means of theſe two ſimple contrivances no manual labour is required from the moment the wheat is taken to the mill till it is converted into flour, and ready to be packed, during the various proceſſes of ſcreening, grinding, ſifting, &c.

That this is a conſiderable improvement is obvious; and we are not without hopes that it may be adopted. The licentiouſneſs of an Engliſh mob has indeed perſecuted an Arkwright, expelled the inventor of the fly-ſhuttle from his native country, and by ſuch conduct prevented the re-erection of the Albion mills, and the general eſtabliſhment of ſaw-mills through the kingdom; but their ſovereignty perhaps will not be rouſed by ſo eaſy and ſimple a contrivance as this to leſſen the quantity of manual labour. For an account of the Dutch oil-mill, which was ſomehow omitted in its proper place in the *Encyclopædia*, ſee *Oil-Mill* in this *Supplement*.

MINERALOGY

1 Definition. IS a ſcience, the object of which is the deſcription and arrangement of *inorganic bodies* or *minerals*; or of *all* the bodies which belong to our globe, excepting *animal* and *vegetable* ſubſtances.

Since the publication of the article Mineralogy, *Encycl.* ſcarcely a ſingle day has paſſed without the diſcovery of ſome new mineralogical fact, or the detection of ſome old and unſuſpected error. Theſe improvements cannot be overlooked in the preſent *Supplement*. But they are ſo numerous in every part of the ſcience, that we can hardly notice them without giving a pretty complete view of the preſent ſtate of mineralogy. This will ſcarcely occupy more room, and muſt be much more uſeful as well as entertaining, than an undigeſted maſs of annotations and remarks. We undertake this taſk the more readily, becauſe in the article Mineralogy in the *Encyclopædia*, the improvements of Mr Werner and his diſciples, to which the ſcience is indebted for a great part of its preſent accuracy, have been entirely overlooked.

2 Object. The object of mineralogy is twofold. 1. To *deſcribe* every mineral with ſo much accuracy and preciſion, that it may be eaſily diſtinguiſhed from every other mineral; 2. To *arrange* them into a ſyſtem in ſuch a manner that every mineral may be eaſily referred to its proper place, and that a perſon may be able, merely by the help of the ſyſtem, to diſcover the *name* of any mineral whatever. When theſe two objects are accompliſhed, mi-

neralogy, ſtrictly ſo called, is completed. But were we to ſtop here, the utility of the ſcience, if it would be entitled to the name of ſcience, could hardly be conſidered as very great. We muſt therefore apply *chemiſtry* to diſcover the ingredients of which minerals are compoſed, and to detect, if poſſible, the laws which theſe ingredients have obſerved in their combination. Thus we ſhall really extend our knowledge of inorganic nature, and be enabled to apply that knowledge to the improvement of almoſt every art and manufacture.

3 Diviſion of the article.

Mineralogy naturally divides itſelf into three parts. The *firſt* treats of the method of deſcribing minerals; the *ſecond*, of the method of arranging them; and the *third* exhibits them in a ſyſtem deſcribed and arranged according to the rules laid down in the two firſt parts. Theſe three parts ſhall be the ſubjects of the following chapters; and we ſhall finiſh the article with a chapter on the chemical analyſis of minerals.

CHAP. I. OF THE DESCRIPTION OF MINERALS.

NOTHING, at firſt ſight, appears eaſier than to deſcribe a mineral, and yet, in reality, it is attended with a great deal of difficulty. The mineralogical deſcriptions of the ancients are ſo looſe and inaccurate, that many of the minerals to which they allude cannot be aſcertained; and conſequently their obſervations, however valuable in themſelves, are often, as far as reſpects us, altogether loſt. It it obvious, that to diſtinguiſh a mineral from every other, we muſt either mention ſome peculiar property, or a collection of properties, which exiſt together in no other mineral. Theſe properties muſt be deſcribed in terms rigidly accurate, which convey preciſe ideas of the very properties intended, and of no other properties. The ſmalleſt deviation from this would lead to confuſion and uncertainty. Now it is impoſſible to deſcribe minerals in this manner, unleſs there be a peculiar term for each of their properties; and unleſs this term be completely underſtood. Mineralogy therefore muſt have a language of its own; that is to ſay, it muſt have a *term* to denote every mineralogical property, and each of theſe terms muſt be accurately defined. The language of mineralogy was invented by the celebrated Werner of Freyberg, and firſt made known to the world by the publication of his treatiſe on *the external characters of minerals*. Of this language we ſhall give a view in the following general deſcription of the properties of minerals (A).

4 Properties of minerals.

The properties of minerals may be divided into two claſſes. *1ſt*, Properties diſcoverable without deſtroying the texture of the mineral; *2d*, Properties reſulting from the action of other bodies on it. The firſt claſs has, by Werner and his diſciples, been called *external* properties, and by ſome French writers *phyſical*; the ſecond claſs has been called *chemical*.

The *external* properties may be arranged under the following heads:

External Characters.

1 Figure.
2 Surface.
3 Tranſparency.
4 Colour.
5 Scratch.
6 Luſtre.
7 Hardneſs.
8 Ductility.
9 Fracture.
10 Texture.
11 Structure.
12 Fragments.
13 Feel.
14 Sound.
15 Smell.
16 Taſte.
17 Gravity.
18 Magnetiſm.
19 Electricity.

5 Figure.

I. By FIGURE is meant the ſhape or form which a mineral is obſerved to have. The *figure* of minerals is either *regular*, *particular*, or *amorphous*. 1. Minerals which aſſume a regular figure are ſaid to be cryſtallized [*]. The *ſides* of a cryſtal are called *faces*; the ſharp line formed by the inclination of two faces is called an *edge*; and the corner, or angle, formed by the meeting of ſeveral edges in one point, is called a *ſolid angle*, or ſimply *an angle*. Thus a cube has ſix faces, twelve edges, and eight angles. 2. Some minerals, though not cryſtallized, affect a *particular* figure. Theſe particular figures are the following: *Globular*, like a globe; *oval*, like an oblong ſpheriod; *ovate*, like an egg; *cheeſe-ſhaped*, a very flattened ſphere; *almond-ſhaped*, like an almond; *centicular*, like a double convex lenſe, compreſſed and gradually thinner towards the edges; *cuneiform*, like a wedge; *nodulous*, having depreſſions and protuberances like a potatoe; *botryoidal*, like grapes cloſely preſſed together; *dentiform*, longiſh and tortuous, and thicker at the bottom than the top; *wireform*, like a wire; *capillary*, like hair, finer than the preceding; *retiform*, threads interwoven like a net; *dendritic*, like a tree, having branches iſſuing from a common ſtem; *ſhrubform*, branches not ariſing from a common ſtem; *coraloidal*, branched like coral; *ſtalactitical*, like iſicles; *clavated*, like a club, long, and thicker at one end than another; *faſciform*, long ſtraight cylindrical bodies, united like a bundle of rods; *tubular*, cylindrical and hollow. 3. When minerals have neither a regular nor particular ſhape, they are ſaid to be *amorphous*.

6 Surface.

II. By SURFACE is meant the appearance of the external ſurface of minerals. The *ſurface* is either *uneven*, compoſed of ſmall unequal elevations and depreſſions; *ſcabrous*, having very ſmall *ſharp* and rough elevations, more eaſily felt than ſeen; *druſy*, covered with very minute cryſtals; *rough*, compoſed of very minute *blunt* elevations, eaſily diſtinguiſhable by the feel; *ſcaly*, compoſed of very minute thin ſcale-like leaves; *ſmooth*, free from all inequality or roughneſs; *ſpecular*, having a ſmooth poliſhed ſurface like a mirror; or *ſtreaked*, having elevated, ſtraight, and parallel lines. This laſt character is confined to the *ſurface* of cryſtals. The *ſtreaks* are either *tranſverſe*; *longitudinal*; *alternate*, in different directions on different faces; *plumoſe*, running from a middle rib; or *decuſſated*, croſſing each other.

7 Tranſparency.

III. By TRANSPARENCY is meant the proportion of light which minerals are capable of tranſmitting. They are *tranſparent* or *pellucid*, when objects can be ſeen diſtinctly through them; *diaphanous*, when objects are ſeen through them indiſtinctly; *ſubdiaphanous*, when light paſſes but in ſo ſmall a quantity that objects cannot be ſeen through them (a); *opaque*, when no light is tranſmitted.

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[*] See CHEMISTRY, Part II. ch. iv. Suppl.

(A) The fulleſt account of Werner's external characters which we have ſeen in the Engliſh language, has been given by Dr Townſon in his *Philoſophy of Mineralogy*. We have availed ourſelves of this book, in order to exhibit ſome of the lateſt improvements of Werner and his diſciples. The reader may alſo conſult *Werner's Treatiſe*, publiſhed at Leipſic in 1774; or the *French tranſlation* publiſhed at Dijon in 1790. See alſo *Romé de Liſle. Des caracters exterieur des mineraux.* And *Hauy Jour. d'hiſt. Nat.* II. 56.

When opaque minerals become tranſparent in water, they are called *hydrophanous*. When objects are ſeen double through a tranſparent mineral, it is ſaid *to refract doubly*.

8 Colour. IV. The colours of minerals may be reduced to eight claſſes.

1. *Whites.*

Snow white. Pure white.

Reddiſh white. White with a light tint of red.

Yellowiſh white. White with a light tint of yellow.

Silver white. Yellowiſh white with a metallic luſtre.

Greyiſh white. White with a light tint of black.

Greeniſh white. White with a light tint of green.

Milk white. White with a light tint of blue.

Tin white. Milk white of a metallic luſtre.

2. *Greys.*

Bluiſh grey. Grey with a little blue.

Lead grey. Bluiſh grey with a metallic luſtre.

Pearl grey. Light grey with a ſlight mixture of violet blue.

Smoke grey. Dark grey with a little blue and brown.

Greeniſh grey. Light grey tinged with green.

Yellowiſh grey. A light grey tinged with yellow.

Steel grey. A dark grey with a light tint of yellow and a metallic luſtre.

Black grey. The darkeſt grey with a tint of yellow.

3. *Blacks.*

Greyiſh black. Black with a little white.

Browniſh black. Black with a tint of brown.

Black. Pure black.

Iron black. Pure black with a ſmall mixture of white and a metallic luſtre.

Bluiſh black. Black with a tint of blue.

4. *Blues.*

Indigo blue. A dark blackiſh blue.

Pruſſian blue. The pureſt blue.

Azure blue. A bright blue with ſcarce a tint of red.

Smalt blue. A light blue.

Violet blue. A mixture of azure blue and carmine.

Lavender blue. Violet blue mixed with grey.

Sky blue. A light blue with a ſlight tint of green.

5. *Greens.*

Verdigris green. A bright green of a bluiſh caſt.

Seagreen. A very light green, a mixture of verdigris green and grey.

Beryl green. The preceding, but of a yellowiſh caſt.

Emerald green. Pure green.

Graſs green. Pure green with a tint of yellow.

Apple green. A light green formed of verdigris green and white.

Leek green. A very dark green with a caſt of brown.

Blackiſh green. The darkeſt green, a mixture of leek green and black.

Piſtachio green. Graſs green, yellow and a little brown.

Olive green. A pale yellowiſh green with a tint of brown.

Aſparagus green. The lighteſt green, yellowiſh with a little brown and grey.

6. *Yellows.*

Sulphur yellow. A light greeniſh yellow.

Braſs yellow. The preceding, with a little leſs green and a metallic luſtre.

Lemon yellow. Pure yellow.

Gold yellow. The preceding with a metallic luſtre.

Honey yellow. A deep yellow with a little reddiſh brown.

Wax yellow. The preceding, but deeper.

Pyritaceous. A pale yellow with grey.

Straw yellow. A pale yellow, a mixture of ſulphur yellow and reddiſh grey.

Wine yellow. A pale yellow with a tint of red.

Ochre yellow. Darker than the preceding, a mixture of lemon yellow with a little brown.

Iſabella yellow. A pale browniſh yellow, a mixture of pale orange with reddiſh brown.

Orange yellow. A bright reddiſh yellow, formed of lemon yellow and red.

7. *Reds.*

Aurora red. A bright yellow red, a mixture of ſcarlet and lemon yellow.

Hyacinth red. A high red like the preceding, but with a ſhade of brown.

Brick red. Lighter than the preceding; a mixture of aurora red and a little brown.

Scarlet red. A bright and high red with ſcarce a tint of yellow.

Copper red. A light yellowiſh red with the metallic luſtre.

Blood red. A deep red, a mixture of crimſon and ſcarlet.

Carmine red. Pure red verging towards a caſt of blue.

Cochineal red. A deep red; a mixture of carmine with a little blue and a very little grey.

Crimſon red. A deep red with a tint of blue.

Fleſh red. A very pale red of the crimſon kind.

Roſe red. A pale red of the cochineal kind.

Peach bloſſom red. A very pale whitiſh red of the crimſon kind.

Mordoré. A dark dirty crimſon red; a mixture of crimſon and a little brown.

Browniſh red. A mixture of blood red and brown.

8. *Browns.*

Reddiſh brown. A deep brown inclining to red.

Clove brown. A deep brown with a tint of carmine.

Yellowiſh brown. A light brown verging towards ochre yellow.

Umber brown. A light brown, a mixture of yellowiſh brown and grey.

Hair brown. Intermediate between yellow brown and clove brown with a tint of grey.

Tombac brown. A light yellowiſh brown, of a metallic luſtre, formed of gold yellow and reddiſh brown.

(a) After Mr Kirwan, we have denoted theſe three degrees of tranſparency by the figures 4, 3, 2. When a mineral is ſubdiaphanous only at the edges, that is denoted by the figure 1. Opacity is ſometimes denoted by 0.

External Characters.

Liver brown. A dark brown; blackiſh brown with a tint of green.

Blackiſh brown. The darkeſt brown.

Colours, in reſpect of intenſity, are either *dark*, *deep*, *light*, or *pale*. When a colour cannot be referred to any of the preceding, but is a mixture of two, this is expreſſed, by ſaying, that the prevailing one *verges* towards the other, if it has only a ſmall tint of it; *paſſes* into it, if it has a greater.

9 Streak.

V. By the SCRATCH or STREAK, is meant the mark left when a mineral is ſcratched by any hard body, as the point of a knife. It is either *ſimilar*, of the ſame colour with the mineral; or *diſſimilar*, of a different colour.

10 Luſtre.

VI. LUSTRE, is the gloſs or brightneſs which appears on the external ſurface of a mineral, or on its internal ſurface when freſh broken. The firſt is called *external*, the ſecond *internal* luſtre. Luſtre is either *common*, that which moſt minerals poſſeſs; *ſilky*, like that of ſilk or mother-of-pearl; *waxy*, like that of wax; *greaſy*, like that of greaſe; or *metallic*, like that of metals.

As to the degree, the greateſt is called *ſplendent*, the next *ſhining*, the third *dulliſh*; and when only a few ſcattered particles ſhine, the luſtre is called *dull* (c).

11 Hardneſs.

VII. We have uſed figures to denote the comparative HARDNESS of bodies; for an explanation of which, we refer to the article CHEMISTRY, Vol. I. p. 224. of this *Supplement*.

12 Ductility and brittleneſs.

VIII. With reſpect to DUCTILITY and BRITTLENESS, minerals are either *malleable*; *ſectile*, capable of being cut without breaking, but not malleable; *flexile*, capable of being bent, and when bent retaining their ſhape; or *elaſtic*, capable of being bent, but recovering their former ſhape. Minerals deſtitute of theſe properties are *brittle*. Brittle minerals, with reſpect to the eaſe with which they may be broken, are either *very tough*, *tough*, *fragile*, or *very fragile*.

13 Fracture.

IX. By FRACTURE is meant the freſh ſurface which a mineral diſplays when broken. It is either *flat*, without any general elevation or depreſſion; or *conchoidal*, having wide extended roundiſh hollows and gentle riſings. When theſe are not *very* evident, the fracture is called *flat* conchoidal; when they are ſmall, it is called *ſmall* conchoidal; and when of great extent, *great* conchoidal.

The fracture may alſo be *even*, free from all aſperities; *uneven*, having many ſmall, ſharp, abrupt, irregular elevations and inequalities; and from the ſize of theſe, this fracture is denominated *coarſe*, *ſmall*, or *fine*; *ſplintery*, having ſmall, thin, half detached, ſharp edged ſplinters, according to the ſize of which this fracture is donominated *coarſe* or *fine*; or *rugged*, having many very minute ſharp hooks, more ſenſible to the hand than the eye.

14 Texture.

X. By TEXTURE is meant the internal ſtructure or diſpoſition of the matter of which a mineral is compoſed, which may be diſcovered by breaking it. The texture is either *compact*, without any diſtinguiſhable parts, or the appearance of being compoſed of ſmaller parts; *earthy*, compoſed of very minute *almoſt* imperceptible rough parts; *granular*, compoſed of ſmall ſhapeleſs grains; *globuliform*, compoſed of ſmall ſpherical bodies; *fibrous*, compoſed of fibres which may be *long*, *ſhort*, *ſtraight*, *crooked*, *parallel*, *divergent*, *ſtellated*, *faſciculated*, or *decuſſated*; *radiated*, conſiſting of long narrow flattiſh lamellæ; or *lamellar* or *foliated*, conſiſting of ſmooth continued plates covering each other: theſe plates may be either *ſtraight*, *crooked*, or *undulating*.

15 Structure.

XI. The STRUCTURE or COMPOUND TEXTURE is the manner in which the parts that form the texture are diſpoſed. It is either *ſlaty*, in ſtraight layers like ſlate; *teſtaceous*, in incurvated layers; *concentric*, in concentric layers; or *columnar*, in columns.

The *texture* and *ſtructure* may at firſt view appear the ſame; but in reality they are very different. Thus common ſlate has often the *ſlaty ſtructure* and *earthy texture*. The texture of pitcoal is compact, but its ſtructure is often ſlaty.

16 Fragments.

XII. By FRAGMENTS is meant the ſhape of the pieces into which a mineral breaks when ſtruck with a hammer. They are either *cubic*; *rhomboidal*; *wedgeſhaped*; *ſplintery*, thin, long, and pointed; *tabular*, thin, and broad, and ſharp at the corners, as common ſlate; or *indeterminate*, without any particular reſemblance to any other body. The *edges* of indeterminate fragments are either *very ſharp*, *ſharp*, *ſharpiſh*, or *blunt*.

17 Feel.

XIII. By the FEEL of minerals is meant the ſenſation which their ſurfaces communicate when handled. The feel of ſome minerals is *greaſy*, of others *dry*, &c.

18 Sound.

XIV. Some minerals when ſtruck give a *clear* SOUND, as common ſlate; others a *dull* ſound.

The SMELL, TASTE, SPECIFIC GRAVITY, and MAGNETISM of minerals, require no explanation.

With reſpect to ELECTRICITY, ſome minerals become electric when *heated*, others when *rubbed*, others cannot be rendered electric. The electricity of ſome minerals is *poſitive* or *vitreous*, of others *negative* or *reſinous*.

As for the CHEMICAL properties of minerals, they have been already explained in the article CHEMISTRY, which makes a part of this *Supplement*. And for the deſcription of the blow-pipe, and the manner of uſing it, we refer the reader to a treatiſe on that ſubject prefixed to the article MINERALOGY in the *Encyclopædia*.

CHAP. II. OF THE ARRANGEMENT OF MINERALS.

MINERALS may be arranged two ways, according to their external characters, and according to their chemical compoſition. The firſt of theſe methods has been called an *artificial* claſſification; the ſecond, a *natural* one. The firſt is indiſpenſably neceſſary for the ſtudent of nature; the ſecond is no leſs indiſpenſable for the proficient who means to turn his knowledge to account. Without the firſt, it is impoſſible to diſcover the *names* of minerals; and without the ſecond, we muſt remain ignorant of their uſe.

Almoſt every ſyſtem of mineralogy hitherto publiſhed, at leaſt ſince the appearance of Werner's *external characters*, has attempted to combine theſe two arrangements, and to obtain at one and the ſame time the advantages peculiar to each. But no attempt of this kind has hitherto ſucceeded. Whether this be owing to any thing impoſſible in the undertaking, or to the preſent

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(c) Theſe four degrees have been denoted by Kirwan by the figures 4, 3, 2, 1, and no luſtre by 0. We have imitated him in the preſent article.

Artificial Syſtem.

preſent imperfect ſtate of mineralogy, as is more probable, we do not take upon us to determine. But ſurely the want of ſucceſs, which has hitherto attended all attempts to combine the two arrangements, ought to ſuggeſt the propriety of ſeparating them. By adhering ſtrictly to one language, the trouble of ſtudying two different ſyſtems would be entirely prevented. They would throw mutual light upon each other: the artificial ſyſtem would enable the ſtudent to diſcover the *names* of minerals; the natural would enable him to arrange them, and to ſtudy their properties and uſes.

The happy arrangement of Cronſtedt, together with the ſubſequent improvements of Bergman, Werner, Kirwan, Hauy, and other celebrated mineralogiſts, has brought the *natural* ſyſtem of mineralogy to a conſiderable degree of perfection. But an *artificial* ſyſtem is ſtill a deſideratum; for excepting Linnæus, whoſe ſucceſs was precluded by the ſtate of the ſcience, no one has hitherto attempted it. Though we are very far from thinking ourſelves ſufficiently qualified for undertaking ſuch a taſk, we ſhall neverthleſs venture, in the next chapter, to ſketch out the rudiments of an artificial ſyſtem. The attempt, at leaſt, will be laudable, even though we ſhould fail.

CHAP. III. ARTIFICIAL SYSTEM.

19 Artificial claſſes.

MINERALS may be divided into ſix claſſes:

1. Minerals that cannot be fuſed by the blow-pipe *per ſe*.
2. Minerals fuſible *per ſe* by the blow-pipe.
3. Minerals fuſible by the blow-pipe *per ſe* when expoſed to the blue flame, but not when expoſed to the yellow flame.
4. Minerals fuſible *per ſe* by the blow-pipe; and when in fuſion, partly evaporating in a viſible ſmoke.
5. Minerals which totally evaporate before the blow-pipe.
6. Minerals totally ſoluble in muriatic acid with efferveſcence, the ſolution colourleſs.

Under theſe heads we ſhall arrange the ſubjects of the mineral kingdom.

CLASS I. INFUSIBLE.

ORDER I. Specific gravity from 16 to 12.
GENUS I. Colour whitiſh iron grey.
Species 1. Native platinum.

ORDER II. Sp. gr. 8.5844 to 7.006.
GENUS I. Attracted by the magnet.
Sp. 1. Native iron.
GENUS II. Not attracted by the magnet.
Sp. 1. Native copper.
Flexible and malleable. Colour uſually red.
Sp. 2. Wolfram.
Brittle. Colour uſually brown or black.

ORDER III. Sp. gr. from 6.4509 to 5.8.
GENUS I. Forms a blue glaſs with microcoſmic ſalt, which becomes colourleſs in the yellow, but recovers its colour in the blue flame.
Sp. 1. Tungſtat of lime.
GENUS II. Forms with microcoſmic ſalt a permanently coloured bead.
Sp. 1. Sulphuret of cobalt.

ORDER IV. Sp. gr. from 4.8 to 4.5.
GENUS I. Tinges borax dark green.
Sp. 1. Common magnetic iron ſtone.
GENUS II. Tinges borax reddiſh brown.
Sp. 1. Grey ore of manganeſe.

Artificial Syſtem.

ORDER V. Sp. gr. from 4.4165 to 3.092. Infuſible with fixed alkalies.
GENUS I. Hardneſs 20.
Sp. 1. Diamond.
GENUS II. Hardneſs 15 to 17. Cauſes ſingle refraction.
Sp. 1. Teleſia.
Sp. 2. Corundum.
GENUS III. Hardneſs 13. Single refraction.
Sp. 1. Ruby.
Cryſtallizes in octohedrons.
GENUS IV. Hardneſs 12. Single refraction.
Sp. 1. Chryſoberyl.
GENUS V. Hardneſs 12. Cauſes double refraction. Becomes electric when heated.
Sp. 1. Topaz.
GENUS VI. Hardneſs 10 to 16. Double refraction. Sp. gr. 4.2 to 4.165.
Sp. 1. Zircon.
GENUS VII. Hardneſs 6 to 9. Feels greaſy.
Sp. 1. Cyanite.
GENUS VIII. Hardneſs 9 to 10. Feel not greaſy. Double refraction. Sp. gr. 3.283 to 3.285.
Sp. 1. Chryſolite.
GENUS IX. Hardneſs 12. Infuſible with borax. Colour of large maſſes black, of thin pieces deep green.
Sp. Ceylanite.
(Phoſphat of lime.)

ORDER VI. Sp. gr. from 2.9829 to 1.987. Infuſible with fixed alkalies.
GENUS I. Hardneſs 12.
Sp. 1. Emerald.
GENUS II. Hardneſs 10.
Sp. 1. Jade.
GENUS III. Hardneſs 6 to 7. Somewhat tranſparent.
Sp. 1. Phoſphat of lime.
Before the blow-pipe becomes ſurrounded with a luminous green vapour.
GENUS IV. Hardneſs 6. Opaque.
Sp. 1. Micarelle.
GENUS V. Stains the fingers. Colour lead grey.
Sp. 1. Plumbago.
Spaniſh wax rubbed with plumbago does not become electric; or if it does, the electricity is negative. Streak lead grey even on earthen ware.

ORDER VII. Sp. gr. from 4.7385 to 4.569. Fuſible with fixed alkalies.
GENUS I. Stains the fingers. Colour lead grey.
Sp. 1 Molybdena.
Spaniſh wax rubbed with molybdena becomes poſitively electric. Streak on earthen ware yellowiſh green.

ORDER VIII. Sp. gr. from 4.1668 to 2.479. Fuſible with fixed alkalies.
* Hardneſs from 10 to 12.

Genus I. Uſually white. Cryſtals dodecahedrons. Double refraction. Fracture imperfectly conchoidal or ſplintery. Brittle.
Sp. 1. Quartz.

Genus II. Uſually dark brown. Fracture perfectly conchoidal. Brittle. Eaſily breaks into ſplinters.
Sp. 1. Flint.

Genus III. Not brittle. Fracture even or imperfectly conchoidal.
Sp. 1. Chalcedony.
Sp. 2. Jaſper.

Genus IV. Forms with potaſs a violet glaſs, with ſoda or borax a brown glaſs, with microcoſmic ſalt a honey yellow glaſs. Colour green. Amorphous.
Sp. 1. Chryſopraſium.

Genus V. Tinges ſoda red. The colour diſappears before the blue flame, and returns before the yellow flame.
Sp. 1. Oxyd of manganeſe and barytes.
Sp. 2. Black ore of manganeſe.
Sp. 3. Carbonat of manganeſe.
(Brown ore of iron. Red ore of iron.)
** Hardneſs 9 to 3.

Genus VI. Flexible and elaſtic in every direction.
Sp. 1. Elaſtic quartz.

Genus VII. Emits white flakes before the blowpipe.
Sp. 1. Blende.

Genus VIII. Becomes electric when heated.
Sp. 1. Calamine.

Genus IX. Tinges borax green. Blackens before the blow-pipe.
Sp. 1. Mountain blue.
Colour blue.
Sp. 2. Green carbonat of copper.
Colour green.

Genus X. Tinges borax green. Becomes attractable by the magnet by the action of the blow-pipe.
Sp. 1. Brown iron ore.
Colour brown.
Sp. 2. Red iron ore.
Colour red.

Genus XI. Tinges borax ſmutty yellow. Becomes browniſh black before the blow-pipe.
Sp. 1. Carbonat of iron.

Genus XII. Feels greaſy.
Sp. 1. Steatites.
(Black ore of Manganeſe. Carbonat of manganeſe. Mica.)

ORDER IX. Sp. gr. from 2.39 to 1.7.

Genus I. Luſtre glaſſy.
Sp. 1. Opal.
Sp. 2. Hyalite.

Genus II. Luſtre greaſy.
Sp. 1. Pitchſtone.

Genus III. Luſtre waxy or pearly.
Sp. 1. Staurolite.

Class II. FUSIBLE.

ORDER I. Sp. gr. from 19 to 10.

Genus I. Colour Yellow.
Sp. 1. Native gold.

Genus II. Colour white.
Sp. 1. Native Silver.

Genus III. Colour yellowiſh white.
Sp. 1. Alloy of ſilver and gold.

ORDER II. Sp. gr. from 7.786 to 4.5.

Genus I. Flexible and malleable.
Sp. 1. Sulphuret of ſilver.
** Brittle.

Genus II. Tinges borax white.
Sp. 1. Tinſtone.

Genus III. Tinges borax green.
Sp. 1. Sulphuret of copper.
Colour bluiſh grey.
Sp. 2. Chromat of lead.
Colour aurora red.
Sp. 3. Purple copper ore.
Colour purple.

Genus IV. Tinges borax faint yellow. Becomes black when expoſed to the vapour of ſulphuret of ammonia.
Sp. 1. Galena.
Colour bluiſh grey. Luſtre metallic. Fragments cubic.
Sp. 2. Black lead ore.
Colour black. Luſtre metallic.
Sp. 3. Lead ochre.
Colour yellow, grey, or red. Luſtre 0.
Sp. 4. Carbonat of lead.
Colour white. Luſtre waxy.
Sp. 5. Phoſphat of lead.
Uſually green. Luſtre waxy. After fuſion by the blow-pipe cryſtallizes on cooling.
Sp. 6. Molybdat of lead.
Colour yellow. Streak white. Luſtre waxy.

ORDER III. Sp. gr. from 4.35 to 3.
* Hardneſs 14 to 9.

Genus I. Melts without frothing into a grey enamel.
Sp. 1. Garnet.
Colour red.

Genus II. Melts into a browniſh enamel.
Sp. 1. Shorl.
Colour black. Opaque.

Genus III. Froths and melts into a white enamel.
Sp. 1. Tourmaline.
Becomes electric by heat.

Genus IV. Froths and melts into a greeniſh black enamel.
Sp. 1. Baſaltine.

Genus V. Froths amd melts into a black enamel.
Sp. 1. Thallite.
Colour dark green.
Sp. 2. Thumerſtone.
Colour clove brown.
** Hardneſs 5 to 8.

Genus VI. Melts into a tranſparent glaſs.
Sp. 1. Fluat of lime.
Powder phoſphoreſces when thrown on a hot iron.

Genus VII. Melts into a black glaſs.

Sp. 1. Hornblende.

Genus VIII. Melts into a black bead with a ſulphureous ſmell, and depoſits a blue oxyd on the charcoal.

Sp. 1. Sulphuret of tin.

Genus IX Melts into a brown glaſs. Tinges borax violet.

Sp. 1. Aſbeſtoid.

Colour green.

Genus X. Melts into a brown (?) glaſs. When fuſed with potaſs, and diſſolved in water, the ſolution becomes of a fine orange yellow.

Sp. 1. Chromat of iron.

Genus XI. Before the blow-pipe yields a bead of copper.

Sp. 1. Red oxyd of copper.

(Sulphuret of copper.)

ORDER IV. Sp. gr. from 2.945 to 2.437.

Genus I. Compoſed of ſcales.

Sp. 1. Talk.

Feels greaſy. Spaniſh wax rubbed by it becomes poſitively electric.

Genus II. Compoſed of thin plates, eaſily ſeparable from each other.

Sp. 1. Mica.

Plates flexible and elaſtic, may be torn but not broken. Spaniſh wax rubbed by it becomes negatively electric.

Sp. 2. Stilbite.

Plates ſomewhat flexible. Colour pearl white. Powder renders ſyrup of violets green. Froths and melts into an opaque white enamel.

Sp. 3. Lepidolite.

Colour violet. Powder white with a tint of red. Froths and melts into a white ſemitranſparent enamel full of bubbles.

Genus III. Texture foliated.

Sp. 1. Felſpar.

Fragments rhomboidal. Hardneſs 9 to 10.

Sp. 2. Leucite.

Always cryſtallized. White. Powder renders ſyrup of violets green. Hardneſs 8 to 10.

Sp. 3. Argentine felſpar.

Always cryſtallized. Two faces dead white, two ſilvery white.

Sp. 4. Prehnite.

Colour green. Froths and melts into a brown enamel.

Genus IV. Texture fibrous. Fibres eaſily ſeparated.

Sp. 1. Aſbeſtus.

Feels ſomewhat greaſy.

Genus V. Texture ſtriated.

Sp. 1. Ædelite.

Abſorbs water. Froths and melts into a frothy maſs.

Genus VI. Texture earthy or compact.

Sp. 1. Lazulite.

Froths and melts into a yellowiſh black maſs. If previouſly calcined, gelatinizes with acids.

Sp. 2. Borat of lime.

Tinges the flame greeniſh, froths and melts into a yellowiſh enamel garniſhed with ſmall projecting points. If the blaſt be continued, theſe dart off in ſparks.

ORDER V. Sp. gr. from 2.348 to 0.68.

Genus I. Hardneſs 10.

Sp. 1. Obſidian.

Colour blackiſh, in thin pieces green.

Genus II. Hardneſs 6 to 8.

Sp. 1. Zeolite.

Gelatinizes with acids. Becomes electric by heat.

Genus III. Hardneſs 3 to 4.

Sp. 1. Amianthus.

Feels greaſy. Texture fibrous.

Sp. 2. Mountain cork.

Elaſtic like cork.

Class III. FUSIBLE by the BLUE FLAME,* INFUSIBLE by the YELLOW.

Genus I. Sp. gr. from 4.43 to 4.4.

Sp. 1. Sulphat of barytes.

Genus II. Sp. gr. from 3.96 to 3.51.

Sp. 1. Sulphat of ſtrontites.

Genus III. Sp. gr. from 2.311 to 2.167.

Sp. 1. Sulphat of lime.

Class IV. FUSIBLE, and partly EVAPORATING.

ORDER I. Sp. gr. from 10 to 5.

Genus I. Colour white or grey. Luſtre metallic.

* Sp. gr. 9 to 10.

Sp. 1. Native amalgam.

Tinges gold white. Creaks when cut.

Sp. 2. Alloy of ſilver and antimony.

Powder greyiſh black.

** Sp. gr. from 6.467 to 5.309.

Sp. 3. Sulphuret of biſmuth.

Melts when held to the flame of a candle.

Sp. 4. Dull grey cobalt ore.

Streak bluiſh grey. Hardneſs 10. When ſtruck, emits an arſenical ſmell. Luſtre ſcarcely metallic.

Genus II. Colour red, at leaſt of the ſtreak.

Sp. 1. Red ſilver ore.

Burns with a blue flame.

Sp. 2. Hepatic mercurial ore.

Does not flame, but gives out mercury before the blow-pipe.

Genus III. Colour blue.

Sp. 1. Blue lead ore.

Burns with a blue flame and ſulphureous ſmell, and leaves a button of lead.

Genus IV. Colour yellowiſh green.

Sp. 1. Phoſphat and arſeniat of lead combined.

When fuſed by the blow-pipe, cryſtallizes on cooling.

Genus V. Colour uſually that of copper. Sp. gr.

Artificial Syſtem.

gr. 6.6084 to 6.6481.
Sp. 1. Sulphuret of nickel.
Exhales before the blow-pipe an arſenical ſmoke.

ORDER II. Sp. gr. from 4.6 to 3.44.
Genus I. Colour grey.
Sp. 1. Grey ore of antimony.
Burns with a blue flame, and leaves a white oxyd.
Sp. 2. Grey copper ore.
Crackles before the blow-pipe.
Genus II. Colour yellow.
Sp. 1. Pyrites.
Burns with a blue flame and ſulphureous ſmell, and leaves a browniſh bead.
Sp. 2. Yellow copper ore.
Melts into a black maſs.

Class V. EVAPORATING.

ORDER I. Sp. gr. 13.6.
Genus I. Fluid.
Sp. 1. Native mercury.

ORDER II. Sp. gr. from 10 to 5.419.
Genus I. Colour red.
Sp. 1. Native cinnabar.
Genus II. Colour white or grey. Luſtre metallic.
Sp. 1. Native biſmuth.
Melts into a white bead, and then evaporates in a yellowiſh white ſmoke. Sp. gr. 9 to 9.5.
Sp. 2. Native antimony.
Melts and evaporates in a grey ſmoke. Sp. gr. 6.6 to 6.8.
Sp. 3. Native arſenic.
Evaporates without melting, and gives out a garlic ſmell.

ORDER III. Sp. gr. from 4.8 to 3.33.
Genus I. Colour red.
Sp. 1. Red antimonial ore.
Melts with a ſulphureous ſmell. Sp. gr. 4.7.
Sp. 2. Realgar.
Melts with a garlic ſmell. Sp. gr. 3.384.
Genus II. Colour yellow.
Sp. 1. Orpiment.

Class VI. SOLUBLE with EFFERVESCENCE in MURIATIC ACID.

Natural Syſtem.

Genus I. Sp. gr. from 4.338 to 4.3.
Sp. 1. Carbonat of barytes.
Genus II. Sp. gr. from 3.66 to 3.4.
Sp. 1. Carbonat of ſtrontites.
Genus III. Sp. gr. from 2.8 to 1 or under.
Sp. 1. Carbonat of lime.

We have purpoſely avoided giving names to the claſſes, orders, and genera; becauſe a more careful examination will doubtleſs ſuggeſt many improvements in the arrangement, and an artificial ſyſtem ought to be brought to a great degree of perfection before its claſſes, orders, and genera, be finally ſettled.

We have excluded from this arrangement all thoſe bodies which in the following ſyſtem are arranged under the claſs of combuſtibles; becauſe there can ſcarcely be any difficulty in diſtinguiſhing them both from the other claſſes and from one another. For ſimilar reaſons we have excluded the claſs of ſalts.

Chap. IV. Natural System.

Avicenna, a writer of the 11th century, divided minerals into four claſſes; ſtones, ſalts, inflammable bodies, and metals (D). This diviſion has been, in ſome meaſure, followed by all ſucceeding writers. Linnæus, indeed, the firſt of the moderns who publiſhed a ſyſtem of mineralogy, being guided by the external characters alone, divided minerals into three claſſes, *petræ*, *mineræ*, *foſſilia*: but Avicenna's claſſes appear among his orders. The ſame remark may be made with reſpect to the ſyſtems of Wallerius, Wolſterdorf, Cartheuſer, and Juſti, which appeared in ſucceſſion after the firſt publication of Linnæus's *Syſtema Naturæ*, in 1736. At laſt, in 1758, the ſyſtem of Cronſtedt appeared. He reinſtated the claſſes of Avicenna in their place; and his ſyſtem was adopted by Bergman, Kirwan, Werner, and the moſt celebrated mineralogiſts who have written ſince. We alſo ſhall adopt his claſſes, with a few ſlight exceptions; becauſe we are not acquainted with any other diviſion which is intitled to a preference.

20 Natural claſſes.

We ſhall therefore divide this treatiſe into four claſſes. I. Stones. II. Salts. III. Combuſtibles. IV. Ores.

The firſt claſs comprehends all the minerals which are compoſed chiefly or entirely of earths; the ſecond, all the combinations of acids and alkalies which occur in the mineral kingdom; the third, thoſe minerals which are capable of combuſtion, and which conſiſt chiefly of ſulphur, carbon, and oil; the fourth, the mineral bodies which are compoſed chiefly of metals.

Class I. EARTHS and STONES.

We ſhall divide this claſs into three orders. The firſt order ſhall comprehend all chemical combinations of earths with each other; the ſecond order, chemical combinations of earths with acids; and the third order, mechanical mixtures of earths or ſtones. All the minerals belonging to the firſt order exhibit the ſame homogeneous appearance to the eye as if they were ſimple bodies. We ſhall therefore, for want of a better name, call the firſt order *ſimple*; the ſecond order we ſhall diſtinguiſh by the epithet of *ſaline*; and the third we ſhall call

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(D) Corpora mineralia in quatuor ſpecies dividuntur, ſcilicet in lapides, et in liquefactiva, ſulphurea, et ſales. Et horum quædam ſunt raræ ſubſtantiæ et debilis compoſitionis, et quædam fortis ſubſtantiæ, et quædam ductibilia, et quædam non. *Avicenna de congelatione et conglutinatione lapidum*, Cap. 3. *Theatrum Chemicum*, t. iv. p. 997.

call *aggregates;* because moſt of the minerals belonging to it conſiſt of various *ſimple ſtones*, cemented, as it were, together.

ORDER I. SIMPLE STONES.

21 Cronſtedt's genera. CRONSTEDT divided this order into nine genera, corresponding to nine earths; one of which he thought compoſed the ſtones arranged under each genus. The names of his genera were, *calcarea*, *ſilicea*, *granatina*, *argillacea*, *micacea*, *fluores*, *aſbeſtina*, *zeolithica*, *magneſia*. All his earths were afterwards found to be compounds, except the firſt, ſecond, fourth, and ninth. Bergman, 22 Improved. therefore, in his Sciagraphia, firſt publiſhed in 1782, reduced the number of genera to five; which was the number of primitive earths known when he wrote. Since that period three new earths have been diſcovered. Accordingly, in the lateſt ſyſtems of mineralogy, the genera belonging to this order amount to eight. Each genus is named from an earth; and they are arranged in the neweſt Wernerian ſyſtem, which we have ſeen, as follows:

1. Jargon genus.
2. Siliceous genus.
3. Glucina genus.
4. Argillaceous genus.
5. Magneſian genus.
6. Calcareous genus.
7. Barytic genus.
8. Strontian genus.

Mr Kirwan, in his very valuable ſyſtem of mineralogy, has adopted the ſame genera. Under each genus, thoſe ſtones are placed, which are compoſed chiefly of the earth which gives a name to the genus, or which at leaſt are ſuppoſed to poſſeſs the characters which diſtinguiſh that earth.

23 Still deficient. A little conſideration will be ſufficient to diſcover that there is no natural foundation for theſe genera. Moſt ſtones are compoſed of two, three, or even four ingredients; and, in many caſes, the proportion of two or more of theſe is nearly equal. Now, under what genus ſoever ſuch minerals are arranged, the earth which gives it a name muſt form the ſmalleſt part of their compoſition. Accordingly, it has not been ſo much the chemical compoſition, as the external character, which has guided the mineralogiſt in the diſtribution of his ſpecies. The genera cannot be ſaid properly to have any character at all, nor the ſpecies to be connected by any thing elſe than an arbitrary title. This defect, which muſt be apparent in the moſt valuable ſyſtems of mineralogy, ſeems to have ariſen chiefly from an attempt to combine together an artificial and natural ſyſtem. As we have ſeparated theſe two from each other, it becomes neceſſary for us to attend more accurately to the natural diſtribution of genera than has hitherto been done. We have accordingly ventured to form new genera for this order, and we have formed them according 24 New genera. to the following rules.

The only ſubſtances which enter into the minerals belonging to this order, in ſuch quantity as to deſerve attention, are the following:

Alumina,
Silica,
Magneſia,
Lime,
Barytes,
Glucina,
Zirconia,
Oxyd of iron,
Oxyd of chromum,
Potaſs,

All thoſe minerals which are compoſed of the *ſame* ingredients we arrange under the *ſame* genus. According to this plan, there muſt be as many genera as there are varieties of combinations of the above ſubſtances exiſting in nature. The varieties in the *proportion* of the ingredients conſtitute ſpecies. We have not impoſed names upon our genera, but, in imitation of Bergman*, have denoted each by a ſymbol. This ſymbol is compoſed of the firſt letter of every ſubſtance which enters in any conſiderable quantity into the compoſition of the minerals arranged under the genus denoted by it. Thus, ſuppoſe the minerals of a genus to be compoſed of *alumina*, *ſilica*, and *oxyd of iron*, we denote the genus by the ſymbol *aſi*. The letters are arranged according to the proportion of the ingredients; that which enters in the greateſt proportion being put firſt, and the others in their order. Thus the genus *aſi* is compoſed of a conſiderable proportion of alumina, of a ſmaller proportion of ſilica, and contains leaſt of all of iron. By this contrivance, the ſymbol of a genus contains, within the compaſs of a few letters, a pretty accurate deſcription of its nature and character. Where the proportions of the ingredients vary in the ſame genus ſo much, that the letters which conſtitute its ſymbol change their place, we ſubdivide the genus into parts; and whenever the minerals belonging to any genus become too numerous, advantage may be taken of theſe ſubdiviſions, and each of them may be formed into a ſeparate genus. At preſent this ſeems unneceſſary (E).

* Opuſc. iv. 231.

The following is a view of the different genera belonging to this order, denoted each by its ſymbol. Every genus is followed by the ſpecies included under it; and the whole are in the order which we mean to follow in deſcribing them:

I. A.
    Teleſia,
    Corundum,
    Native alumina.
II. AMC.
    Ruby.
III. AIM.
    Ceylanite,
IV. S.
    Quartz,
    Elaſtic quartz,
    Flint,
    Opal,
    Pitchſtone,
    Chryſopraſium.
V. 1. AS.
    Topaz,
    Sommite,
    Shorlite.
  2. SA.
    Rubellite,
    Hornſlate,
    Hornſtone,
    Chalcedony,
    Jaſper,
    Tripoli.
VI. 1. ASI.
    Micarell,
    Shorl,
    Granatite,
  2. SAI.
    Tourmaline,
    Argentine felſpar,
    Mica,
    Talc,
    Baſaltine,
    Hornblende,
    Obſidian,
    Petrilite,
    Felſite.
VII. SAP.
    Felſpar,
    Lepidolite,
    Leucite.
VIII. SAG.
    Emerald.
IX. SAB.
    Staurolite.
X. 1. ASL.
    Chryſoberyl.
  2. SAL.
    Hyalite,
    Ædelite.
  3. SAWL.

(E) We need hardly remark, that the laſt three genera of Werner belong to the ſecond order of the firſt claſs of this treatiſe.

3. SAWL.
Zeolite,
Stilbite,
Analcime.
4. SLA.
Lazulite.
XI. SALI.
Garnet,
Thumerſtone,
Prehnite,
Thallite.
XII. 1. AMS.
Cyanite.
2. MSA.
Serpentine.
XIII. MSAI.
Potſtone,
Chlorite.
XIV. SLAM.
Siliceous ſpar.
XV. SAMLI.
Argillite.
XVI. SM.
Kiſſekill,
Steatites.
XVII. MSI.
Chryſolite,
Jade.
XVIII. SML.
Aſbeſtus,
Aſbeſtinite.
XIX. 1. SILM.
Pyroxen,
Aſbeſtoid.
2. SMIL.
Actinolite.
XX. SL.
Shiſtoſe horneſtone.
XXI. ZS.
Zircon.

95
G. I. A.
Teleſia.

GENUS I. A.

SPECIES 1. Teleſia (F).

Oriental ruby, *ſapphire*, and *topaz* of mineralogiſts.—*Rubis d'orient* of De Liſle.

Three ſtones, diſtinguiſhed from each other by their colour, have long been held in high eſtimation on account of their hardneſs and beauty. Theſe ſtones were known among lapidaries by the names of *ruby*, *ſapphire*, and *topaz*, and the epithet *oriental* was uſually added, to diſtinguiſh them from other three, known by the ſame names and the ſame colours, but very inferior in hardneſs and beauty. Mineralogiſts were accuſtomed to conſider theſe ſtones as three diſtinct ſpecies, till Romé de Liſle obſerved that they agreed in the form of their cryſtals, their hardneſs, and moſt of their other properties. Theſe obſervations were ſufficient to conſtitute them one ſpecies; and accordingly they were made one ſpecies by Romé de Liſle himſelf, by Kirwan, and ſeveral other modern mineralogical writers. But this ſpecies was deſtitute of a proper name, till Mr Hauy, whoſe labours, diſtinguiſhed equally by their ingenuity and accuracy, have contributed not a little to the progreſs of mineralogy, denominated it *teleſia*, from the Greek word τελειος, which ſignifies *perfect*.

The teleſia is found in the Eaſt Indies, eſpecially in Pegu and the iſland of Ceylon; and it is moſt commonly cryſtallized. The cryſtals are of no great ſize. Their *primitive* form, according to Mr Hauy, is a regular ſix-ſided priſm, diviſible in directions parallel both to its baſes and its ſides; and conſequently giving for the form of its primitive nucleus, or of its *integrant molecule*, an equilateral three-ſided priſm *. The moſt uſual variety is a dodecahedron, in which the teleſia appears under the form of two very long ſlender ſix-ſided pyramids, joined baſe to baſe †. The ſides of theſe pyramids are iſoſceles triangles, having the angle at their vertex 22° 54′, and each of thoſe at the baſe 78° 48′ (G). The inclination of a ſide of one pyramid to a contiguous ſide of the other pyramid is 139° 54′ †. In ſome ſpecimens the ſummits of the pyramids are wanting, ſo that the cryſtal has the appearance of a ſix-ſided priſm, ſomewhat thicker in the middle than towards the extremities *. The three alternate angles at each extremity of this priſm are alſo ſometimes wanting, and a ſmall triangular face inſtead of them, which renders the baſes of the ſuppoſed priſm nine-ſided. The inclination of each of theſe ſmall triangles to the baſe is 122° 18′ ‡. For figures of theſe cryſtals we refer the reader to Romé de Liſle and Hauy *.

* Ann de Chim. xvii. 313.
† Plate XXXVI. fig. 1.
† Ibid and Romé de Liſle, ii. 315.
* Fig. 2.
‡ Hauy, ibid.
* Ibid.

The texture of the teleſia is foliated, and the joints are parallel to the baſe of the priſm †. Its luſtre varies from 3 to 4 (H). Tranſparency uſually 3 or 4, ſometimes only 2. It cauſes only a ſingle refraction. Specific gravity from 4. to 4.288. Hardneſs from 15 to 17. It is either colourleſs, or red, yellow or blue. Theſe colours have induced lapidaries to divide the teleſia into the three following varieties.

† Hauy.

Variety 1. Red teleſia.
Oriental ruby.

Colour carmine red, ſometimes verging towards violet. Sometimes various colours appear in the ſame ſtone, as red and white, red and blue, orange red. Hardneſs 17. Sp. gr. 4.288.

Variety 2. Yellow teleſia.
Oriental topaz.

Colour golden yellow. Tranſp. 4. Hardneſs 15. Sp. gr. 4.0106.

Variety 3. Blue teleſia.
Oriental ſapphyr.

Colour Berlin blue, often ſo very faint that the ſtone appears almoſt colourleſs. Tranſp. 3, 4, 2. Hardneſs 17. Sp. gr. 3 991 to 4 083 ‡. This variety is not probably the ſame with the ſapphyr of the ancients. Their ſapphyr was diſtinguiſhed by gold-coloured ſpots, none of which are to be ſeen in the ſapphyr of the moderns ||.

‡ Greville, Nicholſon's Jour. iii. 11.
|| Hill's Theophraſtus, περι των λιθων, p. 100.

A ſpecimen of this laſt variety, analyſed by Mr Klaproth, was found to contain in 100 parts,

98.5 alumina,
1.0 oxyd of iron,
0.5 lime,
———
100.0 *.

* Beiträge, i. 81.

The colouring matter of all theſe varieties is, according to Bergman's experiments, iron, in different ſtates of oxydation. He found that the topaz contained .06, the ruby .1, and the ſapphyr .02 of that metal †. But when theſe experiments were made, the analyſis of ſtones was not arrived at a ſufficient degree of perfection to enſure accuracy. No concluſion, therefore, can be drawn from theſe experiments, even though we were certain that they were made upon the real varieties of teleſia.

† Bergman, ii. 98.

SPECIES

(F) See *Kirwan's Mineralogy*, I. 250.—*Gmelin's Syſtema Naturæ of Linnæus*, III. 170.—*Romé de Liſle's Cryſtallographie*, II. 212.—*Bermanni Opuſcula*, II. 72.

(G) In ſome inſtances, the angle at the vertex is 31°, thoſe at the baſe 74° 30′, and the inclination of two triangles 122° 36′. See *Hauy*, *ibid.*

(H) When the *kind* of luſtre is not ſpecified, as in the preſent inſtance, the *common* is always meant.

26
Corundum.

SPECIES 2. Corundum (I).

Corundum of Gmelin—*Adamantine ſpar* of Klaproth and Kirwan—*Corindon* of Hauy—*Corivindum* of Woodward.

This ſtone, though it appears to have been known to Mr Woodward, may be ſaid to have been firſt diſtinguiſhed from other minerals by Dr Black. In 1768, Mr Berry, a lapidary in Edinburgh, received a box of it from Dr Anderſon of Madras. Dr Black aſcertained, that theſe ſpecimens differed from all the ſtones known to Europeans; and, in conſequence of its hardneſs, it obtained the name of *adamantine ſpar.* Notwithſtanding this, it could ſcarcely be ſaid to have been known to European mineralogiſts till Mr Greville of London, who has done ſo much to promote the ſcience of mineralogy, obtained ſpecimens of it, in 1784, from India, and diſtributed them among the moſt eminent chemiſts, in order to be analyſed. Mr Greville alſo learned, that its Indian name was Corundum. It is found in Indoſtan, not far from the river Cavery, which is ſouth from Madras, in a rocky matrix, of conſiderable hardneſs, partaking of the nature of the ſtone itſelf *. It occurs alſo in China; and a ſubſtance, not unlike the matrix of corundum, has been found in Teree, one of the weſtern iſlands of Scotland †.

* *Garrow* and *Greville, Nicholſon's Jour.* ii. 540.
† *Greville, ibid.*

The corundum is uſually cryſtallized. Its primitive form, diſcovered by Mr Hauy ‡ and the Count de Bournon *, is a rhomboidal parallelopiped, whoſe ſides are equal rhombs, with angles of 86° and 94°, according to Bournon, or whoſe diagonals are to each other as $\sqrt{17}$ to $\sqrt{15}$, according to Hauy; which is very nearly the ſame thing †. The moſt common variety, for the primitive form has never yet been found, is the regular ſix-ſided priſm, the alternate angles of which are ſometimes wanting ||, and the triangular faces, which occupy their place, are inclined to the baſe at an angle of 122° 34′ ‡. Sometimes the corundum is cryſtallized in the form of a ſix-ſided pyramid, the apex of which is generally wanting. For a deſcription and figure of theſe, and all the other varieties of corundum hitherto obſerved, we refer the reader to the diſſertation of the Count de Bournon on the ſubject *.

‡ *Jour. de Min.* N° xxviii. 262.
* *Nicholſon's Jour.* ii. 541.
† Fig. 3.
|| Fig. 4
‡ *De Bournon.*
* See alſo *Hauy. Jour. de Min.* N° xxviii. 262.

The texture of the corundum is foliated, and the natural joints are parallel to the faces of the primitive rhomboidal parallelopiped. Luſtre, when in the direction of the laminæ, 3; when broken acroſs, 0. Opake, except when in very thin pieces. Hardneſs 15. Sp. gr. from 3.710 to 4.180 †. Colour grey, often with various ſhades of blue and green.

† *Klaproth.* See alſo *Mr Greville, Nicholſon's Jour.* iii. 11.

According to the analyſis of Klaproth, the corundum of India is compoſed of

89.5 alumina,
5.5 ſilica,
1.25 oxyd of iron,
———
96.25 ‡.

‡ *Beiträge,* i. 77.

A ſpecimen from China of

84.0 alumina,
6.5 ſilica,
7.5 oxyd of iron,
———
98.0 ||.

|| *Ibid.* i. 73.

Notwithſtanding the quantity of ſilica and of iron which theſe analyſes exhibit in the corundum, we have been induced to include it in the preſent genus, on account of the ſtrong reſemblance between it and the third variety of teleſia. The ſtriking reſemblance between the cryſtals of teleſia and corundum will appear evident, even from the ſuperficial deſcription which we have given; and the obſervations of De Bournon * render this reſemblance ſtill more ſtriking. It is not improbable, therefore, as Mr Greville and the Count de Bournon have ſuggeſted, that corundum may be only a variety of teleſia, and that the ſeeming difference in their ingredients is owing to the impurity of thoſe ſpecimens of corundum which have hitherto been brought to Europe. Let not the difference which has been found in the primitive form of theſe ſtones be conſidered as an inſuperable objection, till the ſubject has been again examined with this preciſe object in view; for nothing is eaſier than to commit an overſight in ſuch difficult examinations.

* *Nicholſon's Jour.* iii. 9.

27
Native alumina.

SPECIES 3. Native alumina (K).

This ſubſtance has been found at Halles in Saxony in compact kidney-form maſſes. Its conſiſtence is earthy. Luſtre 0. Opaque. Hardneſs 4. Brittle. Sp. gr. moderate. Feels ſoft, but meagre. Adheres very ſlightly to the tongue. Stains very ſlightly. Colour pure white. Does not readily diffuſe itſelf in water.

It conſiſts of pure alumina, mixed with a ſmall quantity of carbonat of lime, and ſometimes of ſulphat of lime †.

† *Schreber.*

28
G. II. AMC.
Ruby.

GENUS II. AMC.

SPECIES 1. Ruby (L).

Spinel and *balaſs Ruby* of Kirwan—*Ruby* of Hauy—*Rubis ſpinelle octoedre* of De Liſle—*Spinellus* of Gmelin.

This ſtone, which comes from the iſland of Ceylon, is uſually cryſtallized. The primitive form of its cryſtals is a regular octohedron, compoſed of two four-ſided pyramids applied baſe to baſe, each of the ſides of which is an equilateral triangle ‡ (M). In ſome caſes two oppoſite ſides of the pyramids are broader than the other two; and ſometimes the edges of the octohedron are wanting, and narrow faces in their place. For figures and deſcriptions of theſe, and other varieties of theſe cryſtals, we refer the reader to *Romé de Liſle* and the *Abbé Eſtner* *.

‡ Fig. 5.
* *Cryſtall.* ii. 226. *Eſtner's Miner.* 73.

The texture of the ruby is foliated. Its luſtre is 3. Tranſp. 3.4. It cauſes a ſingle refraction. Hardneſs 13. Sp. gr. 3.570 † to 3.625 ‡. Colour red; if deep, the ruby is uſually called *balaſs*; if pale roſy, *ſpinell.*

† *Klaproth.*
‡ *Hatchett* and *Greville.*

(I). See *Kirwan's Mineralogy*, I.—*Klaproth in Beob. der Berlin*, VIII. 295. and *Beiträge*, I. 47.—*Mr Greville* and the *Count de Bournon* in the *Philoſophical Tranſactions* 1798, p. 403. and in *Nicholſon's Journal*, II. 540. and III. 5.—*Mr Hauy Jour. de Phyſ.* XXX. 193. and *Jour. de Min.* N XXVIII. 262.

(K) See *Kirwan's Mineralogy*, I. 175. and *Schreber.* 15. *Stück*, p. 209.

(L) See *Kirwan's Min.* I. 253.—*Romé de Liſle*, II. 224.—*Klaproth Beob. der Berlin*, III. 336. and *Beitrage*, II. 1.—*Vauquelin Ann. de Chim.* XXVII. 3. and XXXI. 141.

(M) We ſhall afterwards diſtinguiſh this octohedron either by the epithet *regular* or *aluminiform*, becauſe it is the well known form of cryſtals of alum.

The ruby, according to the analyſis of Vauquelin, is compoſed of

86.00 alumina,
8.50 magneſia,
5.25 chromic acid.

99.75 *

The ancients ſeem to have claſſed this ſtone among their hyacinths †.

* Ann. de Chim. xxvii. 15.
† Plinii, l. 37. c. 9.

29 G. III. AIM. Ceylanite.

GENUS III. AIM.

SPECIES I. Ceylanite.

The mineral denominated *ceylanite*, from the iſland of Ceylon, from which it was brought into Europe, had been obſerved by Romé de Liſle ‡; but was firſt deſcribed by La Metherie in the Journal de Phyſique for January 1793.

‡ Cryſtal. log. iii. 180. Note 21.

It is moſt commonly found in rounded maſſes; but ſometimes alſo cryſtallized. The primitive form of its cryſtals is a regular octohedron: it commonly occurs under this form, but more commonly the edges of the octohedron are wanting, and ſmall faces in their place ‡.

‡ Hauy, Jour. de Min. Nº xxxviii. 264.

The fracture of the ceylanite is conchoidal *. Its internal luſtre is glaſſy. Nearly opaque, except when in very thin pieces. Hardneſs 12. Sp. gr. from 3.7647 † to 3.793 ‡. Colour of the maſs, black; of very thin pieces, deep green. Powder, greeniſh grey. According to the analyſis of Deſcotils the ceylanite is compoſed of

68 alumina,
16 oxyd of iron,
12 magneſia,
2 ſilica.

98 §.

* Ibid. 263
† Hauy.
‡ Deſcotils.
§ Ann. de Chim. xxiii. 113.

30 G. IV. s. Quartz.

GENUS IV. s.

SPECIES I. Quartz ‖.

This ſtone, which is very common in moſt mountainous countries, is ſometimes cryſtallized, and ſometimes amorphous. The primitive form of its cryſtals, according to Mr Hauy, is a rhomboidal parallelopiped; the angles of whoſe rhombs are 93° 22′, and 86° 38′; ſo that it does not differ much from a cube *. The moſt common variety is a dodecahedron ‡, compoſed of two ſix-ſided pyramids, applied baſe to baſe, whoſe ſides are iſoſceles triangles, having the angle at the vertex 40°, and each of the angles at the baſe 70°; the inclination of a ſide of one pyramid to the contiguous ſide of the other pyramid is 104°. There is often a ſix-ſided priſm interpoſed between the two pyramids, the ſides of which always correſpond with thoſe of the pyramids ‖. For a deſcription and figure of the other varieties of quartz cryſtals, and for a demonſtration of the law which they have followed in cryſtallizing, we refer the reader to *Romé de Liſle* † and *Mr Hauy* ‡.

‖ Kirwan's Min. i. 241.
* Jour de Min, Nº xxviii. 255.
‡ Fig. 6.
Fig. 7.

The texture of quartz is more or leſs foliated. Fracture, conchoidal or ſplintery. Its luſtre varies from 3 to 1, and its tranſparency from 4 to 1; and in ſome caſes it is opaque. It cauſes a double refraction. Hardneſs, from 10 to 11. Sp. gr. from 2.64 to 2.67, and in one variety 2.691. Its colour is exceedingly various; a circumſtance which has induced mineralogiſts to divide it into numerous varieties. Of theſe the following are the chief:

† Cryſtal. ii. 71.
‡ Mem. Par. 1786, p. 78. See alſo Lametherie, Jour. de Phyſ. xlii. 470.

1. Pure colourleſs, perfectly tranſparent cryſtallized quartz, having much the appearance of artificial cryſtal; known by the name of *rock cryſtal*.

2. Quartz leſs tranſparent, and with a ſplintery fracture, has uſually been diſtinguiſhed by the name of *quartz*, and ſeparated from rock cryſtal. As there is no occaſion for this ſeparation, we have, in imitation of Mr Hauy, choſen the word quartz for the *ſpecific name*, comprehending under it all the varieties.

3. Blood red quartz; formerly called *compoſtella hyacinth*, and by Hauy *quartz hematoide*. It owes its colour to oxyd of iron. The mineral known to mineralogiſts by the name of *ſinople*, and conſidered by them as a variety of *jaſper*, has been diſcovered by Dolomieu to be merely this variety of quartz in an amorphous ſtate *.

4. Yellow quartz; called falſe topaz.

5. Roſy red quartz; called Bohemian ruby.

* Jour. de Min. Nº xxviii. 355.

For a fuller enumeration of theſe varieties, we refer the reader to *Sneiſſer's Mineralogy* †, *Kirwan's Mineralogy* ‡, and Gmelin's edition of the *Syſtema Naturæ* of Linnæus §. This laſt writer, however, has arranged ſeveral minerals under quartz which do not belong to it.

† i. 89.
‡ i. 244.
§ iii. 194.

Pure quartz is compoſed entirely of ſilica; but ſome of the varieties of this ſpecies are contaminated with metallic oxyds, and with a ſmall quantity of other earths.

31 Elaſtic quartz.

SPECIES 2. Elaſtic Quartz (N).

This ſingular ſtone is moderately elaſtic, and flexible in every direction. Texture, earthy. Luſtre, 0 or 1. Hardneſs, 9. Brittle. Sp. gr. 2.624. Colour, greyiſh white. Phoſphoreſces when ſcraped with a knife in the dark. The ſpecimen analyſed by Mr Klaproth contained

96.5 ſilica,
2.5 alumina,
5. oxyd of iron,

99.5 †

† Beitrige, ii. 116.

32 Flint.

SPECIES 3. Flint (O).

Pyromachus—*Pierre a fuſil*—*Silex* of Hauy.

This ſtone, which has become ſo neceſſary in modern war, is found in pieces of different ſizes, and uſually of a figure more or leſs globular, commonly among chalk, and often arranged in ſome kind of order. In Saxony it is ſaid to have been found cryſtallized in hexahedrons, compoſed of two low three-ſided pyramids applied baſe to baſe *.

* Gmelin's Syſtema Naturæ, iii. 183.

Its texture is compact. Its fracture, ſmooth conchoidal. Luſtre, external 0, the ſtones being always covered by a white cruſt; internal 1, inclining to greaſy. Tranſp. 2; when very thin, 3. Hardneſs, 10 or 11. Sp. gr. from 2.58 to 2.63. Colour varies from honey yellow to browniſh black. Very brittle, and ſplits into ſplinters in every direction. Two pieces of flint rubbed ſmartly together phoſphoreſce, and emit a peculiar odour. When heated it decrepitates, and becomes white and opaque. When expoſed long to the air

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(N) *Kirwan's Min.* I. 316.—*Gerhard Mem. Berlin*, 1783, 107.—*Klaproth's Beitrage 2 Band.* 113. See alſo *Jour. de Phyſ.* XLI. 91.

(O) *Kirwan's Min.* I. 301.—*Dolomieu Jour de Min.* Nº XXXIII. 693. and *Salivet, ibid.* 713. Theſe laſt gentlemen give the only accurate account of the method of making gun flints.

air it often becomes covered with a white cruſt. A ſpecimen of flint analyſed by Klaproth contained

98.00	ſilica,
.50	lime,
.25	alumina,
0.25	oxyd of iron,
1.00	water.
100.00 †	

† Beiträge, i. 46.

Another ſpecimen analyſed by Dolomieu was compoſed of

97	ſilica,
1	alumina and oxyd of iron,
2	water.
100 ‡	

‡ Jour. de Min. N° xxxiii. 702.

The white cruſt with which flint is enveloped, conſiſts of the ſame ingredients, and alſo a little carbonat of lime. Dolomieu diſcovered that water is eſſential to flint; for when it is ſeparated by heat the ſtone loſes its properties §.

§ Ibid.

The manufacture of gun flints is chiefly confined to two or three departments in France. The operation is exceedingly ſimple: a good workman will make a 1000 flints in a day. The whole art conſiſts in ſtriking the ſtone repeatedly with a kind of mallet, and bringing off at each ſtroke a ſplinter, ſharp at one end and thicker at the other. Theſe ſplinters are afterward ſhaped at pleaſure, by laying the line at which it is wiſhed they ſhould break, upon a ſharp iron inſtrument, and then giving it repeatedly ſmall blows with a mallet. During the whole operation the workman holds the ſtone in his hand, or merely ſupports it on his knee ‖.

‖ Ibid.

33
Opal.

SPECIES 4. Opal (P).

This ſtone is found in many parts of Europe. It is uſually amorphous. Its fracture is conchoidal, commonly ſomewhat tranſparent. Hardneſs from 6 to 10. Sp. gr. from 1.7 to 2.66. The lowneſs of its ſpecific gravity, in ſome caſes, is to be aſcribed to accidental cavities which the ſtone contains. Theſe are ſometimes filled with drops of water. Some ſpecimens of opal have the property of emitting various coloured rays, with a particular effulgency, when placed between the eye and the light. The opals which poſſeſs this property, are diſtinguiſhed by lapidaries by the epithet *oriental;* and often by mineralogiſts by the epithet *nobilis*. This property rendered the ſtone much eſteemed by the ancients.

Variety 1. Opal edler—*Opalus nobilis.*

Luſtre glaſſy, 3. Tranſp. 3 to 2. Hardneſs, 6 to 8. Colour, uſually light bluiſh white, ſometimes yellow or green. When heated it becomes opaque, and ſometimes is decompoſed by the action of the atmoſphere. Hence it ſeems to follow, that water enters eſſentially into its compoſition. A ſpecimen of this variety, analyſed by Klaproth, contained

90	ſilica,
10	water.
100 ¶	

¶ Beiträge, ii. 153.

Variety 2. Semi-opal.

Fracture, imperfectly conchoidal. Luſtre, glaſſy 2. Tranſp. 2 to 3. Hardneſs, 7 to 9. Its colours are very various, greys, yellows, reds, browns, greens of different kinds.

Specimens of this variety ſometimes occur with rifts: theſe readily imbibe water, and therefore adhere to the tongue. Theſe ſpecimens ſometimes become tranſparent when ſoaked in water, by imbibing that fluid. They are then called *hydrophanes*.

Variety 3. Cat's eye *.

* Kirwan's Min. i. 301. Klaproth, Beiträge, i. 90.

This variety comes from Ceylon, and is ſeldom ſeen by European mineralogiſts till it has been poliſhed by the lapidary. Mr Klaproth has deſcribed a ſpecimen which he received in its natural ſtate from Mr Greville of London. Its figure was nearly ſquare, with ſharp edges, a rough ſurface, and a good deal of brilliancy.

Its texture is imperfectly foliated. Luſtre greaſy, 2. Tranſp. 3 to 2. Hardneſs 10. Sp. gr. 2.56 to 2.66. Colour, grey; with a tinge of green, yellow or white: or brown, with a tinge of yellow or red. In certain poſitions it reflects a ſplendid white, as does the eye of a cat; hence the name of this ſtone.

Two ſpecimens, analyſed by Klaproth, the firſt from Ceylon, the other from Malabar, were compoſed of

95.00	94.50	ſilica,
1.75	2.00	alumina,
1.50	1.50	lime,
0.25	0.25	oxyd of iron.
98.5 *	98.25 †	

* Beiträge, i. 94.
† Ibid. p. 96.

34
Pitchſtone.

SPECIES 5. Pitchſtone §.

Menilites.

§ Kir. Min. i. 292.—Daubanton, Mem. Par. 1787, p. 86.

This ſtone, which occurs in different parts of Germany, France, and other countries, has obtained its name from ſome reſemblance which it has been ſuppoſed to have to pitch. It is moſt uſually in amorphous pieces of different ſizes; and it has been found alſo cryſtallized in ſix-ſided priſms, terminated by three-ſided pyramids.

Its texture is conchoidal and uneven, and ſometimes approaches the ſplintery. Luſtre greaſy, from 3 to 1. Tranſp. 2 to 1, ſometimes 0. Hardneſs 8 to 10. Exceedingly brittle; it yields even to the nail of the finger. Sp. gr. 2.049 to 2.39. Its colours are numerous, greyiſh black, bluiſh grey, green, red, yellow of different ſhades. Sometimes ſeveral of theſe colours appear together in the ſame ſtone. A ſpecimen of pitchſtone from Meſnil-montant near Paris *, analyſed by Mr Klaproth, contained

* See Journ. de Phyſ. xxxi. 219.

85.5	ſilica,
11.0	air and water,
1.0	alumina,
.5	iron,
.5	lime and magneſia.
98.5 †	

† Beiträge, ii. 169.

35
Chryſopraſium.

SPECIES 6. Chryſopraſium (Q).

This mineral, which is found in different parts of Germany, particularly near Koſemütz in Sileſia, is always amorphous. Its fracture is either even or inclining to the ſplintery. Scarcely any luſtre. Tranſp. 2 to 3. Hardneſs 10 to 12. Sp. gr. 2.479. Colour, green. In a heat of 130° Wedgewood it whitens and becomes opaque.

(P) *Kirwan's Min.* I. 289.—*Hauy, Jour. d'Hiſt. Nat.* II. 9. *Delius. Nouv. Jour. de Phyſ.* I. 45.
(Q) *Kirwan's Min.* I.—*Lehmann. Mem. Berlin.* 1755. *p.* 202.—*Klaproth Beitrage*, II. 127.

A ſpecimen of this ſtone, analyſed by Mr Klaproth, contained

96.16	ſilica,
1.00	oxyd of nickel,
0.83	lime,
0.08	alumina,
0.08	oxyd of iron.
98.15 ‡	

‡ Beiträge, iii. 133.

36 G. V. 1 AS. Topaz.

GENUS V. 1. AS.

SPECIES 1. Topaz (R).

Occidental ruby, topaz, and *ſapphyr.*

The name *topaz* has been reſtricted by Mr Hauy to the ſtones called by mineralogiſts occidental ruby, topaz, and ſapphyr; which, agreeing in their cryſtallization and moſt of their properties, were arranged under one ſpecies by Mr Romé de Liſle. The word *topaz*, derived from an iſland in the Red Sea (s), where the ancients uſed to find topazes, was applied by them to a mineral very different from ours. One variety of our topaz they denominated *chryſolite.*

The topaz is found in Saxony, Bohemia, Siberia, and Brazil, mixed with other minerals in granite rocks.

It is commonly cryſtallized. The primitive form of its cryſtals is a priſm whoſe ſides are rectangles, and baſes rhombs, having their greateſt angles 124° 22′, and the integral molecule has the ſame form*; and the height of the priſm is to a ſide of the rhomboidal baſes as 3 to 2‡. The different varieties of topaz cryſtals hitherto obſerved, amount to 6. Five of theſe are eight-ſided priſms, terminated by four-ſided pyramids, or wedge-ſhaped ſummits, or by irregular figures of 7, 13, or 15 ſides‖; the laſt variety is a twelve-ſided priſm, terminated by ſix-ſided pyramids wanting the apex. For an accurate deſcription and figure of theſe varieties we refer the reader to Mr Hauy †.

* Hauy, Jour. de Min. N° xxviii, 287.
‡ Fig. 8.
‖ Fig. 9.
† Jour. de Min. ibid.

The texture of the topaz is foliated. Its luſtre is from 2 to 4. Tranſp. from 2 to 4. It cauſes a double refraction. Hardneſs 12 to 14. Sp. gr. from 3.5311 to 3.564. The Siberian and Brazil topazes, when heated, become poſitively electrified on one ſide, and negatively on the other §. It is infuſible by the blow-pipe. The yellow topaz of Brazil becomes red when expoſed to a ſtrong heat in a crucible; that of Saxony becomes white by the ſame proceſs. This ſhews us, that the colouring matter of theſe two ſtones is different.

§ Hauy, ibid.

The colour of the topaz is various, which has induced mineralogiſts to divide it into the following varieties:

1. Red topaz, of a red colour inclining to yellow; called *Brazilian* or *occidental ruby.*

2. Yellow topaz, of a golden yellow colour, and ſometimes alſo nearly white; called *occidental* or *Brazil topaz.* The powder of this and the following variety cauſes ſyrup of violets to aſſume a green colour ‖.

3. *Saxon topaz.* It is of a pale wine yellow colour, and ſometimes greyiſh white.

‖ Vauquelin, Jour. de Min. N° xxix. 165.

4. *Aigue-marine.* It is of a bluiſh or pale green colour.

5. *Occidental ſapphyr.* It is of a blue colour; and ſometimes white.

A ſpecimen of white Saxon topaz, analyſed by Vauquelin, contained

68	alumina,
31	ſilica.
99 ¶	

¶ Jour. de Min. N° xxiv. 3.

37 Sommite.

SPECIES 2. Sommite.

This ſtone was called ſommite by La Metherie, from the moutain Somma, where it was firſt found. It is uſually mixed with volcanic productions. It cryſtallizes in ſix-ſided priſms, ſometimes terminated by pyramids. Colour white. Somewhat tranſparent. Sp. gr. 3.2741. Infuſible by the blow-pipe. According to the analyſis of Vauquelin, it is compoſed of

49	alumina,
46	ſilica,
2	lime,
1	oxyd of iron.
98 *	

* Ibid. N° xxvii. 179.

38 Shorlite.

SPECIES 3. Shorlite †.

This ſtone, which received its name from Mr Klaproth, is generally found, in irregular oblong maſſes or columns, inſerted in granite. Its texture is foliated. Fracture uneven. Luſtre 2. Tranſparency 2 to 1. Hardneſs 9 to 10. Sp. gr. 3.53. Colour greeniſh white, or ſulphur yellow. Not altered by heat. According to the analyſis of Klaproth, it is compoſed of

50	alumina,
50	ſilica.
100	

† Kirwan's Min. i. 286.

39 G. V. 2. BA. Rubellite.

GENUS V. 2 BA.

SPECIES 4. Rubellite (T).

Red ſhorl of Siberia.

This ſtone is found in Siberia mixed with white quartz. It is cryſtallized in ſmall needles, which are grouped together and traverſe the quartz in various directions. Texture fibrous. Fracture even, inclining to the conchoidal. Tranſparency 2; at the edges 3. Hardneſs 10. Brittle. Sp. gr. 3.1. Colour crimſon, blood or peach red. By expoſure to a red heat it becomes ſnow white; but loſes none of its weight. It tinges ſoda blue, but does not melt with it.

According to the analyſis of Mr Bindheim, it is compoſed of

57	ſilica,
35	alumina,
5	oxyds of iron and mangaueſe.
97	

40 Hornſlate.

SPECIES 5. Hornſlate (U).

Sl.ſtcſe porphyry.

This ſtone, which occurs in mountains, is generally amorphous; but ſometimes alſo in columns. Structure

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(R) *Kirwan's Min.* I. 254.—*Pott. Mem. Berlin,* 1747, *p.* 46.—*Margraf, ibid.* 1776. *p.* 73. and 160.—*Henkel. Act. Acad. Nat. Cur.* IV. 316.

(S) It got its name from τοπαζω, *to ſeek;* becauſe the iſland was often ſurrounded with fog, and therefore difficult to find. See *Plinii lb.* 37. *c.* 8.

(T) *Kirwan's Min.* I. 288. *Bindheim. Crell's Annals,* 1792 *p.* 320.

(U) *Kirwan's Min.* I. 307.—*Wiegleb. Crell's Annals,* 1787. 1 *Band.* 302.—See alſo *Reuſs. Samml. Natur. Hiſt. Aufſäze, p.* 207.

ture ſlaty. Texture foliated. Fracture uneven and ſplintery; ſometimes approaching the conchoidal. Luſtre 0. Tranſparency 1 or 0. Hardneſs about 10. Sp. gr. from 2.512 to 2.7. Colour different ſhades of *grey*, from *aſh* to *bluiſh* or *olive green*. Melts at 145° Wedgewood into an enamel. A ſpecimen, analyſed by Wedgewood, contained 73.0 ſilica,
23.9 alumina,
3.5 iron.

100.4

41 Hornſtone. SPECIES 6. Hornſtone (x).

Petroſilex—Chert.

This ſtone, which makes a part of many mountains, is uſually amorphous; but, as Mr Kirwan informs us, it has been found cryſtallized by Mr Beyer on Schneeberg. Its cryſtals are ſix ſided priſms, ſometimes terminated by pyramids; hexahedrons, conſiſting of two three-ſided pyramids applied baſe to baſe; and cubes, or ſix-ſided plates *. Its texture is foliated. Fracture ſplintery, and ſometimes conchoidal. Luſtre 0. Tranſparency 1 to 2. The cryſtals are ſometimes opaque. Hardneſs 7 to 9. Sp. gr. 2.532 to 2.653. Colour uſually dark blue: but hornſtone occurs alſo of the following colours; grey, red, blue, green, and brown of different ſhades †.

[*] Kirwan, i. 303.

[†] Schmeiſſer's Min. i. 103.

According to Kirwan, it is compoſed of
72 ſilica,
22 alumina,
6 carbonat of lime.

100 ‡

[‡] Ibid p. 305.

42 Chalcedony. SPECIES 7. Chalcedony.

This ſtone is found abundantly in many countries, particularly in Iceland and the Faro iſlands. It is moſt commonly amorphous, ſtalactitical, or in rounded maſſes; but it occurs alſo cryſtallized in ſix ſided priſms, terminated by pyramids, or more commonly in four or ſix ſided pyramids, whoſe ſides are convex. Surface rough. Fracture more or leſs conchoidal. Luſtre 1. Somewhat tranſparent. Hardneſs 10 to 11. Sp. gr. 2.56 to 2.665. Not brittle.

According to Bergman, the chalcedony of Faroe is compoſed of 84 ſilica,
16 alumina, mixed with iron.

100

Variety 1. Common chalcedony.

Fracture even, inclining to conchoidal. Tranſparency 2 to 3; ſometimes 1. Its colours are various; it is moſt commonly greyiſh, with a tint of yellow, green, blue, or pearl; often alſo white, green, red, yellow, brown, black, or dotted with red. When ſtriped white and black, or brown, alternately, it is called *onyx*; when ſtriped white and grey, it is called *chalcedonix*. Black or brown chalcedony, when held between the eye and a ſtrong light, appears dark red.

Variety 2. Cornelian.

Fracture conchoidal. Tranſparency 3 to 1; often cloudy. Its colours are various ſhades of red, brown, and yellow. Several colours often appear in the ſame maſs. To this variety belong many of the ſtones known by the name of *Scotch pebbles*.

43 Jaſper. SPECIES 8. Jaſper (y).

This ſtone is an ingredient in the compoſition of many mountains. It occurs uſually in large amorphous maſſes, and ſometimes alſo cryſtallized in ſix-ſided irregular priſms. Its fracture is conchoidal. Luſtre from 2 to 0. Either opaque, or its tranſparency is 1. Hardneſs 9 to 10. Sp. gr. from 2.5 to 2.82. Its colours are various. When heated, it does not decripitate. It ſeems to be compoſed of ſilica and alumina, and often alſo contains iron.

Variety 1. Common jaſper.

Sp. gr. from 2.58 to 2.7. Its colours are, different ſhades of white, yellow, red, brown, and green; often variegated, ſpotted, or veined, with ſeveral colours.

Variety 2. Egyptian pebble.

This variety is found chiefly in Egypt. It uſually has a ſpheroidal or flat rounded figure, and is enveloped in a coarſe rough cruſt. It is opaque. Hardneſs 10. Sp. gr. 2.564. It is chiefly diſtinguiſhed by the variety of colours, which always exiſt in the ſame ſpecimen, either in concentric ſtripes or layers, or in dots or dentritical figures These colours are, different browns and yellows, milk white, and iſabella green; black alſo has been obſerved in dots.

Variety 3. Striped jaſper.

This variety is alſo diſtinguiſhed by concentric ſtripes or layers of different colours: theſe colours are, yellow, browniſh red, and green. It is diſtinguiſhed from the laſt variety by its occurring in large amorphous maſſes, and by its fracture, which is nearly even.

44 Tripoli. SPECIES 9. Tripoli.

This mineral is found ſometimes in an earthy form, but more generally indurated. Its texture is earthy. Its fracture often ſomewhat conchoidal. Luſtre 0. Generally opaque. Hardneſs 4 to 7. Sp. gr. 2.080 to 2.529. Abſorbs water. Feel, harſh dry. Hardly adheres to the tongue. Takes no poliſh from the nail. Does not ſtain the fingers. Colour generally pale yellowiſh grey, alſo different kinds of yellow, brown, and white.

It contains, according to Haaſſe, 90 parts of ſilica, 7 alumina, and 3 of iron. A mineral belonging to this ſpecies was analyſed by Klaproth, and found to contain 66.5 ſilica,
7.0 alumina,
2.5 oxyd of iron,
1.5 magneſia,
1.25 lime,
19. air and water.

97.75

GENUS VI. I. ASI.

45 G. VI. I. ASI. Micarell. SPECIES I. Micarell *.

This name has been given by Mr Kirwan to a ſtone which former mineralogiſts conſidered as a variety of mica. It is found in granite. Its texture is foliated, and

[*] Kirwan's Min i. 211.

(x) *Kirwan's Min*. I. 303.—*Baumer Jour. de Phyſ*. II. 154. and *Monnet*, *ibid*. 331.—*Wiegleb. Crell's Annals*, 1788, *p*. 45 and 135.

(y) *Kirw. Min*. I. 309.—*Borral Hiſt. Natur. de Corſe*.—*Henkel Act. Acad. Nat. Curios*. V. 339.

and it may be ſplit into thin plates. Luſtre metallic, 3. Opaque. Hardneſs 6. Sp. gr. 2.980. Colour browniſh black. At 153° Wedgewood, it melts into a black compact glaſs, the ſurface of which is reddiſh †.

† *Kirw. ibid.*

A ſpecimen analyſed by Klaproth contained

63.00 alumina,
29.50 ſilica,
6.75 iron.

99.25

46 Shorl.

‡ *Ibid.* i. 265.

SPECIES 2. Shorl ‡.

No word has been uſed by mineralogiſts with leſs limitation than *ſhorl*. It was firſt introduced into mineralogy by Cronſtedt, to denote any ſtone of a columnar form, conſiderable hardneſs, and a ſpecific gravity from 3 to 3.4. This deſcription applied to a very great number of ſtones. And ſucceeding mineralogiſts, though they made the word more definite in its ſignification, left it ſtill ſo general, that under the deſignation of *ſhorl* almoſt 20 diſtinct ſpecies of minerals were included.

Mr Werner firſt defined the word *ſhorl* preciſely, and reſtricted it to one ſpecies of ſtones. We uſe the word in the ſenſe aſſigned by him.

Shorl is found abundantly in mountains, either maſſive or cryſtallized, in three or nine ſided priſms, often terminated by three ſided ſummits. The ſides of the cryſtals are longitudinally ſtreaked. Its texture is foliated. Its fracture conchoidal. Luſtre 2. Opaque. Hardneſs 10. Sp. gr. 2.92 to 3.212. Colour black. Streak grey. It does not become electric by heat. When heated to redneſs, its colour becomes browniſh red; and at 127° Wedgewood, it is converted into a browniſh compact enamel *. According to Wiegleb, it is compoſed of

* *Ibid.* i. 266.

41.25 alumina,
34.16 ſilica,
20.00 iron,
5.41 manganeſe.

100.82 †

† *Crell's Beiträge*, 1. *Bandes.* 4 *Stück*, p. 21.

47 Granatite.

SPECIES 5. Granatite.

Staurotide of Hauy—*Pierre de Croix* of De Liſle—*Staurolithe* of Lametherie.

We have adopted from Mr Vauquelin the term *granatite* to denote this ſtone, becauſe all the other names are ambiguous, having been applied to another mineral poſſeſſed of very different properties.

Granatite is found in Galicia in Spain, and Britanny in France. It is always cryſtallized in a very peculiar form; two ſix-ſided priſms interſect each other, either at right angles or obliquely ‡. Hence the name *croſsſtone*, by which it was known in France and Spain *. Mr Hauy has proved, in a very ingenious manner, that the primitive form of the granatite is a rectangular priſm, whoſe baſes are rhombs, with angles of 129½° and 50½°; and that the height of the priſm is to the greater diagonal of a rhomb as 1 to 6; and that its integrant molecules are triangular priſms, ſimilar to what would be obtained by cutting the primitive cryſtal in two, by a plane paſſing vertically through the ſhorter diagonal of the rhomboidal baſe. From this ſtructure he has demonſtrated the law of the formation of the cruciform varieties *. The colour of granatite is greyiſh or reddiſh brown.

‡ Fig. 10.
* *Romé de Liſle*, ii. 435.

* *Ann. de Chim.* vi. 142.

According to the analyſis of Vauquelin, it is compoſed of

47.06 alumina,
30.59 ſilica,
15.30 oxyd of iron,
3.00 lime.

95.95 †

† *Ibid.* xxx. 106.

48 G. VI. 2. Sal. Tourmaline.

GENUS VI. 2. SAL.

SPECIES 4. Tourmaline (z).

This ſtone was firſt made known in Europe by ſpecimens brought from Ceylon; but it is now found frequently forming a part of the compoſition of mountains. It is either in amorphous pieces, or cryſtallized in three or nine ſided priſms, with four-ſided ſummits.

Its texture is foliated: Its fracture conchoidal. Internal luſtre 2 to 3. Tranſparency 3 to 4; ſometimes only 2 (A). Cauſes only ſingle refraction *. Hardneſs 9 to 11. Sp. gr. 3.05 to 3.155. Colour brown, often ſo dark that the ſtone appears black; the brown has alſo ſometimes a tint of green, blue, red, or yellow.

* *Hauy, Jour. de Min.* N° xxvii. 265.

When heated to 200° Fahrenheit, it becomes electric; one of the ſummits of the cryſtal negatively, the other poſitively †. It reddens when heated; and is fuſible *per ſe* with intumeſcence into a white or grey enamel.

† *Æpinus.*

A ſpecimen of the tourmaline of Ceylon, analyſed by Vauquelin, was compoſed of

40 ſilica,
39 alumina,
12 oxyd of iron,
4 lime,
2.5 oxyd of manganeſe,

97.5 ‡.

‡ *Ann de Chim.* xxx. 105.

49 Argentine felſpar.

§ *Kirwan*, i. 327.

SPECIES 5. Argentine felſpar §.

This ſtone was diſcovered by Mr Dodun in the black mountains of Languedoc. It is either amorphous, or cryſtallized in rhomboidal tables, or ſix or eight ſided priſms. Its texture is foliated. Fragments rectangular. Laminæ inflexible. Internal luſtre 4. Tranſparency 2. Colour white; two oppoſite faces of the cryſtals are ſilver white, two others dead white. Hardneſs of the ſilvery laminæ 6, of the reſt 9. Brittle. Sp. gr. 2.5. When the flame of the blow-pipe is directed againſt the edges of the cryſtal (ſtuck upon glaſs), it eaſily melts into a clear compact glaſs; but when the flame is directed againſt the faces, they preſerve their luſtre, and the edges alone ſlowly melt.

According to the analyſis of Dodun, it is compoſed of

46 ſilica,
36 alumina,
16 oxyd of iron,

98

When this ſtone is expoſed to the atmoſphere, it is apt to decay; Its ſurface becomes irideſcent, and at laſt changes to ochre yellow: Its ſpecific gravity is 2.3 or 2.212; and when breathed upon, it gives out an earthy ſmell.

(z) *Kirw.* I. 271.—*Berg.* II. 118. and V. 402.—*Gerhard. Mem. Berlin*, 1777, p. 14.—*Hauy Mem. Par.* 1784, 270.—*Wilſon Phil. Tranſ.* XLI. 308.—*Æpinus. Recueil ſur la Tourmaline.* See alſo *La Porterie. Le Sapphir, l'Oeil de Chat, et la Tourmaline de Ceylon demaſqués.*

(A) And when black only 1.

50
Mica.

SPECIES 6. Mica ‖.

This ſtone forms an eſſential part of many mountains, and has been long known under the names of *glacies mariæ* and *Muſcovy glaſs*. It conſiſts of a great number of thin laminæ adhering to each other, ſometimes of a very large ſize. Specimens have been found in Siberia nearly 2½ yards ſquare (B).

‖ *Kirw.* i. [illegible]0—*Gmelin, Nov. Com. Petropol.* xii. 549.

It is ſometimes cryſtallized: Its primitive form is a rectangular priſm, whoſe baſes are rhombs, with angles of 120° and 60° †: Its integrant molecule has the ſame form. Sometimes it occurs in rectangular priſms, whoſe baſes alſo are rectangles, and ſometimes alſo in ſhort ſix-ſided priſms †; but it is much more frequently in plates or ſcales of no determinate figure or ſize *.

† Fig. 11.

† Fig. 12.

* *Hauy, Jour. de Min.* N° xxviii. 196.

Its texture is foliated. Its fragments flat. The lamellæ flexible, and ſomewhat elaſtic. Luſtre metallic, from 3 to 4. Tranſparency of the laminæ 3 or 4, ſometimes only 2 (C). Hardneſs 6. Very tough. Often abſorbs water. Sp. gr. from 2.6546 to 2.9342. Feels ſmooth, but not greaſy. Powder feels greaſy. Colour, when pureſt, ſilver white or grey; but it occurs alſo yellow, greeniſh, reddiſh, brown, and black. Mica is fuſible by the blow-pipe into a white, grey, green, or black, enamel; and this laſt is attracted by the magnet (D). Spaniſh wax rubbed by it becomes negatively electric *.

* *Ibid.*

A ſpecimen of mica, analyſed by Vauquelin, contained

50.00 ſilica,
35.00 alumina,
7.00 oxyd of iron,
1.35 magneſia,
1.33 lime,

94.68 †.

† *Ibid* 302.

Mica has long been employed as a ſubſtitute for glaſs. A great quantity of it is ſaid to be uſed in the Ruſſian marine for panes to the cabin windows of ſhips; it is preferred, becauſe it is not ſo liable as glaſs to be broken by the agitation of the ſhip.

51
Talc.

SPECIES 7. Talc ‡.

This ſtone has a very ſtrong reſemblance to mica, and was long conſidered as a mere variety of that mineral. It occurs ſometimes in ſmall looſe ſcales, and ſometimes in an indurated form; but it has not hitherto been found cryſtallized.

‡ *Kirw.* i. 150.—*Pott Mem. Berl.* 1746, p 65.

Its texture is foliated. The lamellæ are flexible, but not elaſtic. Its luſtre is from 2 to 4. Tranſparency from 2 to 4. Hardneſs 4 to 6. Sp. gr. when indurated, from 2.7 to 2.8. Feels greaſy. Colour moſt commonly whitiſh or greeniſh. Spaniſh wax rubbed with it becomes *poſitively* electric §.

§ *Hauy, Jour. de Min.* N° xxviii. 291.

Variety 1. Scaly talc.

Talcite of Kirwan.

This variety occurs under the form of ſmall ſcales, ſcarcely cohering. Luſtre 3 to 4. Very light. Adheres to the fingers. When rubbed upon the ſkin, it gives it a gloſs. Colour white, with a ſhade of red or green; ſometimes leek green.

Variety 2. Common talc.

Venatian talc.

This variety often occurs in oblong nodules. Luſtre, nearly metallic, 4. Tranſparency 2 to 3; when very thin 4. Hardneſs 4 to 5. Colour white, with a ſhade of green or red; or apple green, verging towards ſilver white. By tranſmitted light green.

Variety 3. Shiſtoſe talc.

Its ſtructure is ſlaty. Fracture hackly and long ſplintery. Eaſily crumbles when rubbed in the fracture. External luſtre 2 to 3; internal, 1; but ſometimes, in certain poſitions, 3. Colour grey, with a ſhade of white, green or blue. Becomes white and ſcaly when expoſed to the air.

A ſpecimen of *common talc*, analyſed by Mr Chenevix, contained

48.0 ſilica,
37.0 alumina,
6.0 oxyd of iron,
1.5 magneſia,
1.5 lime,
5.0 water,

99 0 *.

* *Ann. de Chim.* xxviii. 200

52
Baſaltine.

SPECIES 8. Baſaltine †.

Baſaltic hornblende of Werner—*Actinote* of Hauy—*Zillertite* of Lametherie—*Shorl priſmatique hexagone* of Sauſſure.

† *Kirw.* i. 219.

This ſtone is found commonly in baſaltic rocks; hence its name, which we have borrowed from Mr Kirwan. It is cryſtallized, either in rhomboidal priſms, or ſix or eight ſided priſms, terminated by three-ſided pyramids. Its texture is foliated. Its fracture uneven. Luſtre 3. Tranſparency, when in very thin plates, 1. Hardneſs from 9 to 10. Sp. gr. 3.333. Colour black, dark green, or yellowiſh green. Streak white. Tranſmits a reddiſh yellow light. Before the blow-pipe, it melts into a greyiſh coloured enamel, with a tint of yellow †. A ſpecimen, ſeemingly of this ſtone, analyſed by Bergman, contained

58 ſilica,
27 alumina,
9 iron,
4 lime,
1 magneſia,

99 ‡.

† *Le Lievre, Jour de Min.* N° xxviii. 269.

‡ *Berg.* iii. 207.

53
Hornblende.

SPECIES 9. Hornblende ¶.

Amphibole of Hauy (E).

This ſtone enters into the compoſition of various mountains. Its texture is very conſpicuouſly foliated. Fracture conchoidal. Fragments often rhomboidal. Luſtre 2. Opaque. Hardneſs 5 to 9. Tough. Sp. gr. 2.922 to 3.41. Colour black, blackiſh green, olive green

¶ *Kirw.* i. 213.

(B) *Hiſt. General de Voyages*, T. XVIII. 272, quoted by Hauy *Jour. de Min.* N° XXVIII. 299.

(C) Black mica is often nearly opaque.

(D) *Hauy, ibid.* p. 295. Bergman, however, found pure mica infuſible *per ſe*; and this has been the caſe with all the ſpecimens of Muſcovy glaſs which we have tried.

(E) We ſuſpect, that under this name Mr Hauy comprehends *ſhorl* alſo.

green, or leek green. Streak greeniſh. It neither becomes electric by friction nor heat *. Before the blow-pipe it melts into a black glaſs. A ſpecimen of black hornblende, analyſed by Mr Hermann, was compoſed of

37 ſilica,
27 alumina,
25 iron,
5 lime.
3 magneſia,

97 †

54 Reſplendent hornblende.

SPECIES 10. Reſplendent Hornblende.

There are two minerals which Werner conſiders as varieties of hornblende, and Mr Kirwan as conſtituting a diſtinct ſpecies. Theſe, till future analyſes decide the point, we ſhall place here under the name of reſplendent hornblende, the name given them by Mr Kirwan; and we ſhall deſcribe them ſeparately.

Variety 1. Labradore hornblende.

Texture, curved foliated. Luſtre, in ſome poſitions, 0; in others metallic, and from 3 to 4. Opaque. Hardneſs 8 to 9. Sp. gr. from 3.35 to 3.434. Colour, in moſt poſitions, greyiſh black; in others, it reflects a ſtrong iron grey, ſometimes mixed with copper red.

Variety 2. Shiller ſpar *.

Texture foliated. Luſtre metallic, 4. Tranſparency, in thin pieces, 1. Hardneſs 8 to 9. Sp. gr. 2.882. Colour green, often with a ſhade of yellow; alſo golden yellow. In ſome poſitions it reflects white, grey, or yellow. At 141° Wedgewood, hardened into a porcelain maſs. A ſpecimen, analyzed by Gmelin, was compoſed of

43.7 ſilica,
17.9 alumina,
23.7 iron,
11.2 magneſia.

96.5 †

It has been found in the Hartz, ſtuck in a ſerpentine rock.

55 Obſidian.

SPECIES 11. Obſidian ‖.

Iceland agate.

This ſtone is found either in detached maſſes, or forming a part of the rocks which compoſe many mountains. It is uſually inveſted with a grey or opaque cruſt. Its fracture is conchoidal. Its internal luſtre 3. Tranſparency 1. Hardneſs 10. Sp. gr. 2.348. Colour black or greyiſh black; when in very thin pieces, green. It melts into an opaque grey maſs. According to Bergman, it is compoſed of

69 ſilica,
22 alumina,
9 iron.

100 §.

56 Petrilite.

SPECIES 12. Petrilite *.

Cubic felſpar.

This ſtone is found in the maſs of mountains. It is amorphous. Texture foliated. Fracture ſplintery. Fragments cubic, or inclining to that form; their faces unpoliſhed. Luſtre 2. Tranſparency partly 2, partly 1. Hardneſs 9. Sp. gr. 3.081. Colour reddiſh brown. Does not melt at 160° Wedgewood.

57 Felſite.

SPECIES 13. Felſite †.

Compact felſpar.

This ſtone alſo forms a part of many mountains, and is amorphous. Texture ſomewhat foliated. Fracture uneven, approaching to the ſplintery. Luſtre 1. Tranſparency ſcarce 1. Hardneſs 9. Colour azure blue, and ſometimes brown and green. Streak white. Before the blow-pipe, whitens and becomes rifty; but is infuſible *per ſe*.

58 G VII. SAP. Felſpar.

GENUS VII. SAP.

SPECIES 1. Felſpar ‡.

This ſtone forms the principal part of many of the higheſt mountains. It is commonly cryſtallized. Its primitive form, according to De Liſle, is a rectangular priſm, whoſe baſes are rhombs, with angles of 65° and 115° †. Sometimes the edges of the priſm are wanting, and faces in their place; and ſometimes this is the caſe alſo with the acute angles of the rhomb. For a deſcription and figure of theſe, and other varieties, we refer the reader to *Romé de Liſle* *, *Mr Hauy* †, and *Mr Pini* ‡.

Its texture is foliated. Its croſs fracture uneven. Fragments rhomboidal, and commonly ſmooth and poliſhed on four ſides. Luſtre of the poliſhed faces often 3. Tranſparency from 3 to 1. Hardneſs 9 to 10. Sp. gr. from 2.437 to 2.7. Gives a peculiar odour when rubbed. It is made electric with great difficulty by friction. Fuſible *per ſe* into a more or leſs tranſparent glaſs. When cryſtallized, it decrepitates before the blow-pipe.

Variety 1. Pure Felſpar.

Moon ſtone—Adularia.

This is the pureſt felſpar hitherto found. It occurs in Ceylon and Switzerland; and was firſt mentioned by Mr Sage. Luſtre nearly 3. Tranſparency 2 to 3. Hardneſs 10. Sp. gr. 2.559. Colour white; ſometimes with a ſhade of yellow, green, or red. Its ſurface is ſometimes irideſcent.

Variety 2. Common Felſpar.

Luſtre of the croſs fracture 0; of the fracture, in the direction of the laminæ, from 3 to 1. Tranſparency 2 to 1. Colour moſt commonly fleſh red; but often bluiſh grey, yellowiſh white, milk white, browniſh yellow; and ſometimes blue, olive green, and even black.

Variety 3. Labradore felſpar.

This variety was diſcovered on the coaſt of Labradore by Mr Wolfe; and ſince that time it has been found in Europe. Luſtre 2 to 3. Tranſparency from 1 to 3. Sp. gr. from 2.67 to 2.6925. Colour grey. In certain poſitions, ſpots of it reflect a blue, purple, red, or green colour.

Variety 4. Continuous felſpar.

This variety moſt probably belongs to a different ſpecies; but as it has not hitherto been analyſed, we did not think ourſelves at liberty to alter its place.

It is found in large maſſes. Texture earthy. Fracture uneven, ſometimes ſplintery. Luſtre 0. Tranſparency 1. Hardneſs 10. Sp. gr. 2.609. Colour reddiſh grey, reddiſh yellow, fleſh red.

A ſpecimen of green felſpar from Siberia, analyſed by Vauquelin, contained

62.83 ſilica,
17.02 alumina,
16.00 potaſs,
3.00 lime,
1.00 oxyd of iron.

99.85 ‖

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* Hauy, Jour. de Min. N° xxviii. 267.

† Beob. der Berlin, 5. Band 317.

* Kirw. i. 241.

† Bergbaukunde, 1 Band. p. 92.

‖ Kirw. i. 264.

§ Berg. iii. 204.

* Kirw. i. 325.

† Kirw. i. 326.

‡ Kirw. i. 316. and Jour. de Phyſ. paſſim.

† Fig. 13. and 14.

* Cryſtall. ii. 461.

† Mem. Par 1784, p. 273.

‡ Sur de Nouvelle Cryſtalliſation, &c. 8.

‖ Ann. de Chim. xxx.

59 Lepidolite.

SPECIES 2. Lepidolite (F).

Lilalite.

This ſtone appears to have been firſt obſerved by the Abbé Poda, and to have been firſt deſcribed by De Born §. Hitherto it has only been found in Moravia in Germany, and Sudermania in Sweden *. There it is mixed with granite in large amorphous maſſes. It is compoſed of thin plates, eaſily ſeparated, and not unlike thoſe of mica †. Luſtre, pearly 3. Tranſparency between 1 and 2. Hardneſs 4 to 5. Not eaſily pulveriſed ‡. Sp. gr. from 2.816 ‖ to 2.8549 ¶. Colour of the maſs, violet blue; of the thin plates, ſilvery white. Powder white, with a tint of red §. Before the blowpipe, it froths, and melts eaſily into a white ſemitranſparent enamel, full of bubbles. Diſſolves in borax with effervefcence, and communicates no colour to it *. Effervefces ſlightly with ſoda, and melts into a maſs ſpotted with red. With microcoſmic ſalt, it gives a pearl coloured globule †.

§ *Crell's Annals*, 1791, ii. 196.
* *Beyer, Ann. de Chim.* xxix. 108.
† *Le Lievre, Jour. de Min.* N° li. 219.
‡ *Ibid.*
‖ *Klaproth.*
¶ *Hauy.*
§ *Le Lievre, Jour de Min.* N° li. 219.
* *Ibid*
† *Klaproth, Ann. de Chim.* xxii. 37.

This ſtone was firſt called lilalite from its colour, that of the *lily*. Klaproth, who diſcovered its component parts, gave it the name of *lepidolite* (G).

It is compoſed of

53	ſilica,
20	alumina,
18	potaſs,
5	fluat of lime,
3	oxyd of manganeſe,
1	oxyd of iron.
100 ‡	

‡ *Vauquelin, Ann. de Chim.* xxx. 105.

60 Leucite.

SPECIES 3. Leucite ‖.

Veſuvian of Kirwan—*White garnet* of Veſuvius.

This ſtone is uſually found in volcanic productions, and is very abundant in the neighbourhood of Veſuvius. It is always cryſtallized. The primitive form of its cryſtals is either a cube or a rhomboidal dodecahedron, and its integrant molecules are tetrahedrons; but the varieties hitherto obſerved are all polyhedrons: The moſt common has a ſpheroidal figure, and is bounded by 24 equal and ſimilar trapeziods †; ſometimes the faces are 12, 18, 36, 54, and triangular, pentagonal, &c. For a deſcription and figure of ſeveral of theſe, we refer the reader to Mr Hauy ‖. The cryſtals vary from the ſize of a pin head to that of an inch.

‖ *Kirw.* i. 285.
† Fig. 15.
‖ *Jour. de Min.* N° xxvii. 185.

The texture of the leucite is foliated. Its fracture ſomewhat conchoidal. Luſtre 3; when in a ſtate of decompoſition 0. Tranſparency 3 to 2; when decompoſing 0. Hardneſs 8 to 10; when decompoſing 5 to 6. Sp. gr. 2.4648. Colour white, or greyiſh white (H). Its powder cauſes ſyrup of violets to aſſume a green colour*.

* *Vauquelin, Jour. de Min.* N° xxxix. 165.

It is compoſed, as Klaproth has ſhewn, of

54	ſilica,
23	alumina,
22	potaſs.
99 (I)	

It was by analyſing this ſtone that Klaproth diſcovered the preſence of potaſs in the mineral kingdom; which is not the leaſt important of the numerous diſcoveries of that accurate and illuſtrious chemiſt.

Leucite is found ſometimes in rocks which have never been expoſed to volcanic fire; and Mr Dolomieu has rendered it probable, from the ſubſtances in which it is found, that the leucite of volcanoes has not been formed by volcanic fire, but that it exiſted previouſly in the rocks upon which the volcanoes have acted, and that it was thrown out unaltered in fragments of theſe rocks §.

§ *Jour. de Min.* N° xxxix. 177.

GENUS VIII. SAG.

61 G. VIII. SAG Emerald.

SPECIES 1. Emerald (K).

This ſtone has hitherto been only found cryſtallized. The primitive form of its cryſtals is a regular ſix-ſided priſm; and the form of its integrant molecules is a triangular priſm, whoſe ſides are ſquares, and baſes equilateral triangles *. The moſt common variety of its cryſtals is the regular ſix-ſided priſm, ſometimes with the edges of the priſm, or of the baſes, or the ſolid angles, or both wanting ‡, and ſmall faces in their place †. The ſides of the priſm are generally channelled.

* *Hauy, Jour. de Min.* N° xix. 72.
‡ Fig. 16.
† *Romé de Liſle*, ii. 245. and *Hauy, ibid.*

Its texture is foliated. Its fracture conchoidal. Luſtre uſually from 3 to 4. Tranſparency from 2 to 4. Cauſes a double refraction. Hardneſs 12. Sp. gr. 2.65 to 2.775. Colour green. Becomes electric by friction, but not by heat. Its powder does not phoſphoreſce when thrown on a hot iron †. At 150° Wedgewood it melts into an opaque coloured maſs. According to Dolomieu, it is fuſible *per ſe* by the blow-pipe ‡.

† *Dolomieu, Jour. de Min.* N° xviii. 19.
‡ *Ibid.*

This mineral was formerly ſubdivided into two diſtinct ſpecies, the *emerald*, and *beryl* or *aqua marina*. Hauy demonſtrated, that the emerald and beryl correſponded exactly in their ſtructure and properties, and Vauquelin found that they were compoſed of the ſame ingredients; henceforth, therefore, they muſt be conſidered as varieties of the ſame ſpecies.

The variety formerly called *emerald* varies in colour from the pale to the perfect green. When heated to 120° Wedgewood, it becomes *blue*, but recovers its colour when cold. A ſpecimen, analyſed by Vauquelin, was compoſed of

64.60	ſilica,
14.00	alumina,
13.00	glucina,
3.50	oxyd of chromum,
2.56	lime,
2.00	moiſture or other volatile ingredient.
99.66 ‖	

‖ *Ann. de Chim.* xxvi. 264.

The *beryl* is of a greyiſh green colour, and ſometimes blue, yellow, and even white: ſometimes different colours appear in the ſame ſtone §. It is found in Ceylon, different parts of India, Brazil, and eſpecially in Siberia and Tartary, where its cryſtals are ſometimes a foot long ¶.

§ *Dolomieu, ibid.*
¶ *Ibid.*

(F) *Kirw.* I. 208.—*Karſten. Beob. der Berlin*, 5 *Band.* 71.—*Klaproth Beiträge*, I. 279. and II. 191.

(G) That is, *ſcale ſtone*, or ſtone compoſed of ſcales: From λεπις, *the ſcale of a fiſh*, and λιθος, *a ſtone*.

(H) Hence the name leucite, from λευκος, *white*.

(I) See *Jour. de Min.* N° XXVII. 194. and 201. and *Klaproth's Beiträge*, II. 39.

(K) *Kir.* I. 247. and 248.—*Dolomieu. Magazin Encyclopedique*, II. 17. and 145.; and *Jour. de Min.* N° XVIII. 19.—*Klaproth Beiträge*, II. 12.

long. A ſpecimen of beryl, analyſed by Vauquelin, contained

69	ſilica,
13	alumina,
16	glucina,
1.5	oxyd of iron.
99.5‖	

‖ Ann. de Chim. xxviii. 168.

It was by analyſing this ſtone that Vauquelin diſcovered the earth which he called *glucina*.

62 G. IX SAB. Staurolite.

GENUS IX. SAB.

SPECIES I. Staurolite*.

* Kirw. i. 282.

Andreolite of Lametherie and Hauy—*Hyacinthe blanche cruciforme*, var. 9. of Romé de Liſle.

This ſtone has been found at Andreaſberg in the Hartz. It is cryſtallized, and the form of its cryſtals has induced mineralogiſts to give it the name of *croſs-ſtone*. Its cryſtals† are two four-ſided flattened priſms, terminated by four-ſided pyramids, interſecting each other at right angles: the plane of interſection paſſing longitudinally through the priſms (L).

† Fig. 17.

Its texture is foliated. Its luſtre waxy, 2. Tranſparency from 1 to 3. Hardneſs 9. Brittle. Sp. gr. 2.355 to 2.361. Colour milk white. When heated ſlowly, it loſes 0 15 or 0.16 parts of its weight, and falls into powder. It effervesces with borax and microcoſmic ſalt, and is reduced to a greeniſh opaque maſs. With ſoda it melts into a frothy white enamel. When its powder is thrown on a hot coal, it emits a greeniſh yellow light†.

† Hauy, Jour. de Min. Nº xxviii. 280.

A ſpecimen analyſed by Weſtrum was compoſed of

44	ſilica,
20	alumina,
20	barytes,
16	water.
100	

Klaproth found the ſame ingredients, and nearly in the ſame proportions‡.

‡ Beiträge, ii. 80.

A variety of ſtaurolite has been found only once, which has the following peculiarities.

Its luſtre is pearly, 2. Sp. gr. 2.361. Colour browniſh grey. With ſoda it melts into a purpliſh and yellowiſh frothy enamel. It is compoſed, according to Weſtrum, of

47.5	ſilica,
12.0	alumina,
20.0	barytes,
16.0	water,
4.5	oxyds of iron and mangeneſe.
100.0	

63 G. X. ASL. Chryſoberyl.

GENUS X. I. ASL.

SPECIES I. Chryſoberyl*.

* Kirw. i. 261.

Oriental chryſolite of jewellers—*Cymophane* of Hauy.

Hitherto this ſtone has been found only in Brazil, the iſland of Ceylon, and as ſome affirm near Nertſchink in Siberia. Werner firſt made it a diſtinct ſpecies, and gave it the name which we have adopted. It is uſually found in round maſſes about the ſize of a pea, but it is ſometimes alſo cryſtallized. The primitive form of its cryſtals is a four-ſided rectangular priſm, whoſe height is to its breadth as √3 to 1, and to its thickneſs as √2 to 1†. The only variety hitherto obſerved is an eight-ſided priſm, terminated by ſix ſided ſummits‡. Two of the faces of the priſm are hexagons, two are rectangles, and four trapeziums; two faces of the ſummits are rectangles, and the other four trapeziums. Sometimes two of the edges of the priſm are wanting, and ſmall faces in their place†.

† Fig. 18.
‡ Fig. 19.
† Hauy, Jour. de Min. Nº xxi. 5.

Its texture is foliated. Laminæ parallel to the faces of the priſm. Luſtre 3 to 4. Tranſparency 3 to 4. Cauſes ſingle refraction. Hardneſs 12. Sp. gr. from 3.698‡ to 3.7961‖. Colour yellowiſh green, ſurface ſparkling. It is infuſible by the blow pipe *per ſe*, and with ſoda.

‡ Werner.
‖ Hauy.

A ſpecimen of chryſoberyl, analyſed by Klaproth, was compoſed of

71.5	alumina,
18.0	ſilica,
6.0	lime,
1.5	oxyd of iron.
97.0§	

§ Beiträge, i. 102.

64 G. X. 2. SAL. Hyalite.

GENUS X. 2. SAL.

SPECIES 2. Hyalite*.

* Kirw. i. 296.

This ſtone is frequently found in trap. It occurs in grains, filaments, and rhomboidal maſſes. Texture foliated. Fracture uneven, inclining to conchoidal. Luſtre glaſſy (M), 2 to 3. Tranſparency 2 to 3; ſometimes, tho' ſeldom, it is opaque. Hardneſs 9. Sp. gr. 2.11†. Colour pure white. Infuſible at 150° Wedgewood; but it yields to ſoda‡. According to Mr Link, it is compoſed of

† Kirwan.
‡ Id.

57	ſilica,
18	alumina,
15	lime.
90	and a very little iron‖.

‖ Crell's Annals, 1790, 2 Band. 232.

65 Ædelite.

Species 3. Ædelite*.

* Kirw. i. 276.

This ſtone has hitherto been found only in Sweden at Moſſeberg and Ædelfors. From this laſt place Mr Kirwan, who firſt made it a diſtinct ſpecies, has given it the name which we have adopted. It was firſt mentioned by Bergman†. Its form is tuberoſe and knotty. Texture ſtriated; ſometimes reſembles quartz. Luſtre from 0 to 1. Sp. gr. 2.515 after it has abſorbed water‡. Colour light grey, often tinged red; alſo yellowiſh brown, yellowiſh green and green. Before the blow-pipe it intumeſces and forms a frothy maſs. Acids convert it into a jelly §. A ſpecimen from Moſſeberg, analyſed by Bergman, contained

† Opuſc. vi. 101.
‡ See Kirwan's Min. i. 276.
§ Berg. iii. 227.

69	ſilica,
20	alumina,
8	lime,
3	water.
100‖	

‖ Opuſc. vi. 101.

A ſpecimen from Ædelfors yielded to the ſame chemiſt

62	ſilica,
18	alumina,
16	lime,
4	water.
100¶	

¶ Ibid.

GENUS

(L) See *Gillot*, *Jour. de Phyſ.* 1793, p. 1 and 2.

(M) Hence probably the name *hyalite*, which was impoſed by Werner from ὑαλος, *glaſs*, and λιθος, *a ſtone*.

GENUS X. 3. SAWL.

SPECIES 4. Zeolite (N).

66 G. X. 3. SAWL. Zeolite.

This ſtone was firſt deſcribed by Cronſtedt in the Stockholm Tranſactions for 1756. It is found ſometimes amorphous and ſometimes cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are ſquares. The moſt common variety is a long four-ſided priſm, terminated by low four-ſided pyramids*.

Its texture is ſtriated or fibrous. Its luſtre is ſilky, from 3 to 1. Tranſparency from 2 to 4; ſometimes 1. Hardneſs 6 to 8; ſometimes only 4. Abſorbs water. Sp. gr. 2.07 to 2.3. Colour white, often with a ſhade of red or yellow; ſometimes brick red, green, blue. When heated, it becomes electric like the tourmaline†. Before the blow-pipe it froths (O), emits a phoſphoreſcent light, and melts into a white ſemitranſparent enamel, too ſoft to cut glaſs, and ſoluble in acids. In acids it diſſolves ſlowly and partially without effervеſcence; and at laſt, unleſs the quantity of liquid be too great, it is converted into a jelly.

* Hauy, Jour. de Min. N° xiv. 86.

† Hauy, ibid. N° xxviii. 276.

A ſpecimen of zeolite (P), analyſed by Vauquelin, contained

53.00	ſilica,
27.00	alumina,
9.46	lime,
10.00	water.
99.46‡.	

‡ Ibid. N° xiv. 576.

SPECIES 5. Stilbite.

67 Stilbite.

This ſtone was firſt formed into a diſtinct ſpecies by Mr Hauy. Formerly it was conſidered as a variety of zeolite.

The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are rectangles. It cryſtallizes ſometimes in dodecahedrons, conſiſting of a four-ſided priſm with hexagonal faces, terminated by four-ſided ſummits, whoſe faces are oblique parallelograms; ſometimes in ſix-ſided priſms, two of whoſe ſolid angles are wanting, and a ſmall triangular face in their place*.

* Hauy, Jour. de Min. N° xiv. 86.

Its texture is foliated. The laminæ are eaſily ſeparated from each other; and are ſomewhat flexible. Luſtre pearly, 2 or 3 (Q). Hardneſs inferior to that of zeolite, which ſcratches ſtilbite. Brittle. Sp. gr. 2.500†. Colour pearl white. Powder bright white, ſometimes with a ſhade of red. This powder, when expoſed to the air, cakes and adheres as if it had abſorbed water. It cauſes ſyrup of violets to aſſume a green colour. When ſtilbite is heated in a porcelain crucible, it ſwells up and aſſumes the colour and ſemitranſparency of baked porcelain. By this proceſs it loſes 0.185 of its weight. Before the blow-pipe it froths like borax, and then melts into an opaque white coloured enamel §.

† Hauy, ibid. N° xxviii. 276.

§ Vauquelin, ibid. N° xxix. 161.

According to the analyſis of Vauquelin, it is compoſed of

52.0	ſilica,
17.5	alumina,
9.0	lime,
18.5	water.
97.0‖	

‖ Ibid. 164.

SPECIES 6. Analcime.

68 Analcime.

This ſtone, which was diſcovered by Mr Dolomieu, is found cryſtallized in the cavities of lava. It was firſt made a diſtinct ſpecies by Mr Hauy. Mineralogiſts had formerly confounded it with zeolite.

The primitive form of its cryſtals is a cube. It is ſometimes found cryſtallized in cubes, whoſe ſolid angles are wanting, and three ſmall triangular faces in place of each; ſometimes in polyhedrons with 24 faces. It is uſuall ſomewhat tranſparent. Hardneſs about 8; ſcratches glaſs ſlightly. Sp. gr. above 2. When rubbed, it acquires only a ſmall degree of electricity, and with difficulty (R). Before the blow-pipe it melts without frothing, into a white ſemitranſparent glaſs*.

* Hauy, Jour. de Min. N° xiv. 86. and xxviii. 278.

GENUS X. 4. SLA.

SPECIES 7. Lazulite†.

69 G. X. 4. SLA. Lazulite.

This ſtone, which is found chiefly in the northern parts of Aſia, has been long known to mineralogiſts by the name of *lapis lazuli*. This term has been contracted into *lazulite* by Mr Hauy; an alteration which was certainly proper, and which therefore we have adopted.

† Kirw. i. 283.

Lazulite is always amorphous. Its texture is earthy. Its fracture uneven. Luſtre 0. Opaque, or nearly ſo. Hardneſs 8 to 9 Sp. gr. 2.76 to 2.945‡. Colour blue (S); often ſpotted white from ſpecks of quartz, and yellow from particles of pyrites.

‡ Briſſon.

It retains its colour at 100° Wedgewood; in a higher heat it intumeſces, and melts into a yellowiſh black maſs. With acids it efferveſces a little, and if previouſly calcined, forms with them a jelly.

Margraff publiſhed an analyſis of lazulite in the Berlin Memoirs for 1758. His analyſis has ſince been confirmed by Klaproth, who found a ſpecimen of it to contain

46.0	ſilica,
14.5	alumina,
28.0	carbonat of lime,
6.5	ſulphat of lime,
3.0	oxyd of iron,
2.0	water.
100.0§	

§ Beiträge, i. 196.

GENUS XI. SALI.

SPECIES 1. Garnet (T).

70 G. XI. SALI. Garnet.

This ſtone is found abundantly in many mountains. It is uſually cryſtallized. The primitive form of its cryſtals

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(N) *Kirw.* I. 278.—*Guettard*, IV. 637.—*Bucquet*, *Mem. Sav. Etrang.* IX. 576.—*Pelletier*, *Jour. de Phyſ.* XX. 420.

(O) Hence the name *zeolite*, given to this mineral by Cronſtedt; from ζεω, *to ferment*, and λιθος, *a ſtone*.

(P) Dr Black was accuſtomed to mention, in the courſe of his lectures, that Dr Hutton had diſcovered *ſoda* in zeolite. This diſcovery has not hitherto been verified by any other chemical mineralogiſt.

(Q) Hence the name given to this mineral by Hauy, *ſtilbite*, from στιλβω, *to ſhine*.

(R) Hence the name *analcime* given it by Hauy, from αναλκις, *weak*.

(S) Hence the name *lazulite*, from an Arabian word *azul*, which ſignifies *blue*.

(T) *Kirw.* I. 258.—*Gerhard*, *Diſquiſitio phyſico-chymica Granatorum*, &c.—*Paſumot*, *Jour. de Phyſ.* IIII. 442.—*Wiegleb*, *Ann. de Chim.* I. 231.

cryſtals is a dodecahedron whoſe ſides are rhombs, with angles of 78° 31′ 44″, and 120° 28′ 16″. The inclination of the rhombs to each other is 120°. This dodecahedron may be conſidered as a four-ſided priſm, terminated by four-ſided pyramids*. It is diviſible into four parallelopipeds, whoſe ſides are rhombs; and each of theſe may be divided into four tetrahedrons, whoſe ſides are iſoſceles triangles, equal and ſimilar to either of the halves into which the rhomboidal faces of the dodecahedron are divided by their ſhorter diagonal. The integrant molecules of garnet are ſimilar tetrahedrons†. Sometimes the edges of the dodecahedron are wanting, and ſmall faces in their place; and ſometimes garnet is cryſtallized in polyhedrons, having 24 trapezoidal faces. For a deſcription and figure of theſe, and other varieties of garnet, we refer to *Romé de Liſle* and *Hauy*‡.

* Fig. 20.
* *De Liſle*, ii. 322 and *Hauy*, *Ann. de Chim.* xvii. 305.
† *Hauy*, *ibid.* 306.
‡ *Ibid.*

The texture of garnet, as Bergman firſt ſhewed, is foliated ‖. Its fracture commonly conchoidal. Internal luſtre from 4 to 2. Tranſparency from 2 to 4; ſometimes only 1 or 0. Cauſes ſingle refraction §. Hardneſs from 10 to 14. Sp. gr. 3.75 to 4.188. Colour uſually red. Often attracted by the magnet. Fuſible *per ſe* by the blow pipe.

‖ *Opuſc.* ii. 9.
§ *Hauy*, *Jour. de Min.* N° xxviii. 260.

Variety 1. Oriental garnet (v).

Internal luſtre 3 to 4. Tranſparency 4. Hardneſs 13 to 14. Sp. gr. 4 to 4.188. Colour deep red, inclining to violet (x).

Variety 2. Common garnet.

Fracture uneven, inclining to the conchoidal. Internal luſtre 2 to 3. Tranſparency from 3 to 0. Hardneſs 10 to 11; ſometimes only 9. Sp. gr. 3.75 to 4. Colour commonly deep red, inclining to violet; ſometimes verging towards black or olive; ſometimes leek green, brown, yellow.

Variety 3. Amorphous garnet.

Structure ſlaty. Luſtre 2. Tranſparency 2 to 1. Hardneſs 11 to 12. Sp. gr. 3.89. Colour browniſh or blackiſh red. Found in Sweden, Switzerland, and the Eaſt Indies.

A ſpecimen of oriental garnet, analyſed by Klaproth, contained

35.75	ſilica,
27.25	alumina,
36.00	oxyd of iron,
0.25	oxyd of manganeſe.
99.25*	

* *Beiträge*, ii. 26.

A ſpecimen of red garnet, analyſed by Vauquelin, contained

52.0	ſilica,
20.0	alumina,
17.0	oxyd of iron,
7.7	lime.
96.7†	

† *Jour. de Min.* N° xliv. 575.

A ſpecimen of black garnet yielded to the ſame chemiſt

43	ſilica,
16	alumina,
20	lime,
16	oxyd of iron,
4	moiſture.
99‡.	

‡ *Ibid.* 573.

Mr Klaproth found a ſpecimen of Bohemian garnet, compoſed of

40.00	ſilica,
28.50	alumina,
16.50	oxyd of iron,
10.00	magneſia,
3.50	lime,
.25	oxyd of manganeſe.
98.75¶	

¶ *Beiträge*, ii. 21.

SPECIES 2. Thumerſtone*.

71 Thumerſtone.

Yanolite of Lametherie—*Axinite* of Hauy.

This ſtone was firſt deſcribed by Mr Schreber, who found it near Balme d'Auris in Dauphiné, and gave it the name of *ſhorl violé*†. It was afterwards found near Thum in Saxony, in conſequence of which Werner called it *thumerſtone*.

* *Kirw.* i. 273.—*Pelletier*, *Jour. de Phyſ.* xxvi. 66.
† *De Liſle*, ii. 353.

It is ſometimes amorphous; but more commonly cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are parallelograms with angles of 101° 32′ and 78° 28′‡. The moſt uſual variety is a flat rhomboidal parallelopiped, with two of its oppoſite edges wanting, and a ſmall face in place of each §. The faces of the parallelopiped are generally ſtreaked longitudinally.

‡ *Hauy*, *Jour. de Min* N° xxviii. 264.
§ Fig. 21.
§ *De Liſle*, *ibid.*

The texture of thumerſtone is foliated. Its fracture conchoidal. Luſtre 2. Tranſparency, when cryſtallized, 3 to 4; when amorphous, 2 to 1. Cauſes ſimple refraction ‖. Hardneſs 10 to 9. Sp. gr. 3.2956. Colour clove brown; ſometimes inclining to red, green, grey, violet, or black. Before the blow-pipe it froths like zeolite, and melts into a hard black enamel. With borax it exhibits the ſame phenomena, or even when the ſtone is ſimply heated at the end of a pincer¶.

‖ *Hauy*, *ibid.*
¶ *Vauquelin*, *Jour. de Min.* N° xxiii. 1.

A ſpecimen of thumerſtone, analyſed by Klaproth, contained

52.7	ſilica,
25.6	alumina,
9.4	lime,
9.6	oxyd of iron with a trace of manganeſe.
97.3*	

* *Beiträge*, ii. 126.

A ſpecimen, analyſed by Vauquelin, contained

44	ſilica,
18	alumina,
19	lime,
14	oxyd of iron,
4	oxyd of manganeſe.
99†	

† *Jour. de Min. ibid.*

SPECIES 3. Prehnite (y).

72 Prehnite.

Though this ſtone had been mentioned by Sage†, Romé de Liſle*, and other mineralogiſts, Werner was the firſt who properly diſtinguiſhed it from other minerals, and made it a diſtinct ſpecies. The ſpecimen which he examined was brought from the Cape of Good Hope by Colonel Prehn; hence the name *prehnite*, by which he diſtinguiſhed it. It was found near Dumbarton by Mr Grotche†; and ſince that time it has been obſerved in other parts of Scotland.

† *Miner.* i. 232.
* *Cryſtallog.* ii. 275.
† *Ann. de Chim.* i. 113.

(v) This ſeems to be the *carbuncle* (ανθραξ) of Theophraſtus, and the *carbunculus garamanticus* of other ancient writers. See *Hill's Theophraſtus* περι λιθων, p. 74 and 77.

(x) Hence, according to many, the name *garnet* (in Latin *granatus*), from the reſemblance of the ſtone in colour to the bloſſoms of the pomegranate.

(y) *Kirw.* I. 274.—*Haſſenfratz*, *Jour. de Phyſ.* XXXII. 81.—*Sage*, *ibid.* XXXIV. 446.—*Klaproth*, *Beob. der Berlin*, 2 *Band.* 211. And *Ann. de Chim.* I. 201.

It is both amorphous and cryſtallized. The cryſtals are in groups, and confuſed: they ſeem to be four-ſided priſms with dihedral ſummits ‡. Sometimes they are irregular ſix ſided plates, and ſometimes flat rhomboidal parallelopipeds.

‡ *Hauy, Jour. de Min* N° xxviii. 277.

Its texture is foliated. Fracture uneven. Internal luſtre pearly, ſcarcely 2. Tranſparency 3 to 2. Hardneſs 9 to 10. Brittle. Sp. gr. 2.6969 ‖. Colour apple green, or greeniſh grey. Before the blow-pipe it froths more violently than zeolite, and melts into a brown enamel. A ſpecimen of prehnite, analyſed by Klaproth, was compoſed of

‖ *Hauy, ibid.*

43.83	ſilica,
30.33	alumina,
18.33	lime,
5.66	oxyd of iron,
1.16	air and water.
99.31 §	

§ *Ann. de Chim.* i. 206.

Whereas Mr Haſſenfratz found in another ſpecimen

50.0	ſilica,
20.4	alumina,
23.3	lime,
4.9	iron,
.9	water,
.5	magneſia.
100.0 ¶	

¶ *Ibid* and *Jour. de Phyſ.* N° xxiii. 81.

SPECIES 4. Thallite.

73 Thallite

Green ſhorl of Dauphiné of De Liſle*—*Delphinite* of Sauſſure.

* *Cryſtallog.* ii. 401.

This ſtone is found in the fiſſures of mountains; and hitherto only in Dauphiné and on Chamouni in the Alps.

It is ſometimes amorphous, and ſometimes cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are rhombs with angles of 114° 37′, and 65° 23′ †. The moſt uſual variety is an elongated four-ſided priſm (often flattened), terminated by four-ſided incomplete pyramids §; ſometimes it occurs in regular ſix-ſided priſms ‡. The cryſtals are often very ſlender.

† *Hauy, Jour. de Min.* N° xxviii 271.
§ Fig. 22.
‡ *Romé de Liſle, ibid.* and *Hauy, Jour. de Min.* N° xix 415.

Its texture appears fibrous. Luſtre inconſiderable. Tranſparency 2 to 3, ſometimes 4; ſometimes nearly opaque. Cauſes ſingle refraction. Hardneſs 9 to 10. Brittle. Sp. gr. 3.4529 to 3.46. Colour dark green (z). Powder white or yellowiſh green, and feels dry. It does not become electric by heat. Before the blow-pipe, froths and melts into a black ſlag. With borax melts into a green bead ‖.

‖ *Hauy,* and *Deſcotils, ibid.*

A ſpecimen of thallite, analyſed by Mr Deſcotils, contained

37	ſilica,
27	alumina,
17	oxyd of iron,
14	lime,
1.5	oxyd of manganeſe.
96.5 §	

§ *Ibid* N° xx. 420.

GENUS XII. 1. AMS.

SPECIES 1. Cyanite*.

74 G. XII. AMS Cyanite.

Sappare of Sauſſure.

* *Kirw.* I. 209.—*Sage, Jour. de Phyſ.* xxxv. 39.

This ſtone was firſt deſcribed by Mr Sauſſure, the ſon, who gave it the name of *ſappare* †. It is commonly found in granite rocks. The primitive form of its cryſtals is a four-ſided oblique priſm, whoſe ſides are inclined at an angle of 103°. The baſe forms with one ſide of the priſm an angle of 103°; with another, an angle of 77°. It is ſometimes cryſtallized in ſix-ſided priſms ‡.

† *Jour. de Phyſ.* xxxiv. 213.
‡ *Hauy, Jour. de Min.* N° xxviii. 282.

Its texture is foliated. Laminæ long. Fragments long, ſplintery. Luſtre pearly, 2 to 3. Tranſparency of the laminæ 3. Cauſes ſingle refraction ‖. Hardneſs 6 to 9. Brittle. Sp. gr. from 3.092 to 3.622 §. Feels ſomewhat greaſy. Colour milk white, with ſhades of ſky or pruſſian blue (A); ſometimes bluiſh grey; ſometimes partly bluiſh grey, partly yellowiſh or greeniſh grey.

‖ *Hauy, ibid.*
§ *Kirwan.*

Before the blow-pipe it becomes almoſt perfectly white; but does not melt. According to the analyſis of Sauſſure, it is compoſed of

66.92	alumina,
13.25	magneſia,
12.81	ſilica,
5.48	iron,
1.71	lime.
100.17 ¶	

¶ *Jour. de Phyſ. ibid.*

Cyanite has alſo been analyſed by Struvius and Hermann, who agree with Sauſſure as to the ingredients; but differ widely from him and one another as to the proportions.

Struvius.		Hermann.	
5.5	- - -	30	alumina,
30.5	- - -	39	magneſia,
51.5	- - -	23	ſilica,
5.0	- - -	2	iron,
4.0	- - -	3	lime
96.5*		97†	

* *Crell's Annals*, 1790.
† *Ibid.*

GENUS XII. 2. MSA.

SPECIES 2. Serpentine (B).

75 G. XII. 2. MSA Serpentine.

This ſtone is found in amorphous maſſes. Its fracture is ſplintery. Luſtre 0. Opaque. Hardneſs 6 to 7. Sp. gr. 2.2645 to 2.709. Feels rather ſoft, almoſt greaſy. Generally emits an earthy ſmell when breathed upon. Its colours are various ſhades of green, yellow, red, grey, brown, blue: commonly one or two colours form the ground, and one or more appear in ſpots or veins (C).

Before the blow-pipe it hardens and does not melt.

A ſpecimen of ſerpentine, analyſed by Mr Chenevix, contained

34.5	magneſia,
28.0	ſilica,
23.0	alumina,
4.5	oxyd of iron,
0.5	lime,
10.5	water.
101.0*	

* *Ann. de Chim.* xxviii 199.

GENUS

(z) Hence the name *thallite* given it by Lametherie, from θαλλος, *a green leaf.*

(A) Hence the name *cyanite*, impoſed by Werner.

(B) *Kirw.* I. 156.—*Margraf, Mem. Berlin*, 1759, p. 3.—*Bayen, Jour. de Phyſ.* XIII. 45.—*Mayer, Crell's Annals*, 1789, II. 416.

(C) Hence the name *ſerpentine*, given to the ſtone from a ſuppoſed reſemblance in colours to the ſkin of ſerpent.

GENUS XIII. MSAI.

76 G. XIII. MSAI. Potſtone. † Kirw. i. 155.

SPECIES 1. Potſtone †.

This ſtone is found in neſts and beds, and is always amorphous. Its ſtructure is often ſlaty. Texture undulatingly foliated. Luſtre from 1 to 3. Tranſparency from 1 to 0; ſometimes 2. Hardneſs 4 to 6. Brittle. Sp. gr. from 2.8531 to 3.023. Feels greaſy. Sometimes abſorbs water. Colour grey with a ſhade of green, and ſometimes of red or yellow; ſometimes leek green; ſometimes ſpeckled with red.

Potſtone is not much affected by fire; and has therefore been made into utenſils for boiling water; hence its name.

According to Wiegleb, the potſtone of Como contains

38	magneſia,
38	ſilica,
7	alumina,
5	iron,
1	carbonat of lime,
1	fluoric acid.
90	

77 Chlorite. * Kirw. i. 247.

SPECIES 2. Chlorite *.

This mineral enters as an ingredient into different mountains. It is ſometimes amorphous, and ſometimes cryſtallized in oblong, four-ſided, acuminated cryſtals. Its texture is foliated. Its luſtre from 0 to 2. Opaque. Hardneſs from 4 to 6; ſometimes in looſe ſcales. Colour green.

Variety 1. Farinaceous chlorite.

Compoſed of ſcales ſcarcely cohering, either heaped together, or inveſting other ſtones. Feels greaſy. Gives an earthy ſmell when breathed on. Difficult to pulveriſe. Colour graſs green; ſometimes greeniſh brown; ſometimes dark green, inclining to black. Streak white. When the powder of chlorite is expoſed to the blowpipe it becomes brown. Before the blow-pipe, farinaceous chlorite froths and melts into a dark brown glaſs; with borax it forms a greeniſh brown glaſs *.

Variety 2. Indurated chlorite.

This variety is cryſtallized. Luſtre 1. Hardneſs 6. Feel meage. Colour dark green, almoſt black. Streak mountain green.

Variety 3. Slaty chlorite.

Structure ſlaty. Fragments flatted. Internal luſtre 1 to 2. Hardneſs 5. Colour greeniſh grey, or dark green inclining to black. Streak mountain green.

A ſpecimen of the firſt variety, analyſed by Vauquelin, contained

43.3	oxyd of iron,
26.0	ſilica,
15.5	alumina,
8.0	magneſia,
2.0	muriat of potaſs,
4.0	water.
98.8 †	

A ſpecimen of the ſame variety yielded Mr Hapner

12.92	oxyd of iron,
37.50	ſilica,
4.17	alumina,
43.75	magneſia,
1.66	lime.
100.0 ‡	

A ſpecimen of the ſecond variety, analyſed by the ſame chemiſt, contained

10.15	oxyd of iron,
41.15	ſilica,
6.13	alumina,
39.47	magneſia,
1.50	lime,
1.50	air and water.
99.9 §	

On the ſuppoſition that theſe analyſes are accurate, the enormous difference between them is a demonſtration that chlorite is not a chemical combination, but a mechanical mixture.

GENUS XIV. SLAM.

78 G. XIV. SLAM. Siliceous ſpar.

SPECIES 1. Siliceous ſpar (D).

This ſtone has been found in Tranſylvania. It is cryſtallized in 4 or 6 ſided priſms, channelled tranſverſely, and generally heaped together. Its texture is fibrous. Its luſtre ſilky, 2. Its colours white, yellow, green, light blue. According to Bindheim, it contains

61.1	ſilica,
21.7	lime,
6.6	alumina,
5.0	magneſia,
1.3	oxyd of iron,
3.3	water.
99.0 *	

GENUS XV. SAMLI.

79 G. XV. SAMLI. Argillite. † Kirw. i. 234.

SPECIES 1. Argillite †.

Argillaceous ſhiſtus—Common ſlate.

This ſtone conſtitutes a part of many mountains.

Its ſtructure is ſlaty. Its texture foliated. Fracture ſplintery. Fragments often tabular. Luſtre moſt commonly ſilky, 2; ſometimes 0. Tranſparency from 0 to 1. Hardneſs from 5 to 8. Sp. gr. from 2.67 to 2.88. Does not adhere to the tongue. Gives a clear ſound when ſtruck. Often imbibes water. Streak white or grey. Colour moſt commonly grey, with a ſhade of blue, green, or black; ſometimes purpliſh, yellowiſh, mountain green, brown, bluiſh black; ſometimes ſtriped or ſpotted with a darker colour than the ground.

It is compoſed, according to Kirwan, of ſilica, alumina, magneſia, lime, oxyd of iron. In ſome varieties the

* Vauquelin, Jour. de Min. No xxxix. 167.

† Ann. de Chim xxx. 106.

‡ Sauſſure's Voyages, ii. 133.

§ Crell's Annals, 1790, p. 56.

* Berg. vi. 104.

(D) Is this the *tremolite* of Lowitz from the lake Baikal in Siberia? If ſo, the name of the genus ought to be SLM; for he found it to contain no alumina. According to his analyſis, it was compoſed of

52	ſilica,
20	lime,
12	carbonat of lime,
12	magneſia,
96	

Earths and Stones.

the lime is wanting. Several varieties contain a conſiderable quantity of carbonaceous matter.

GENUS XVI. SLACMI.

SPECIES I. Smaragdite.

80
G. XVI.
SLACMI.
Smaragdite.

This ſtone was called *ſmaragdite* by Mr Sauſſure, from ſome reſemblance which it has to the emerald. Its texture is foliated. The laminæ are inflexible. Fracture even. Hardneſs 7. Colour in ſome caſes fine green, in others it has the grey colour and metallic luſtre of mica: it aſſumes all the ſhades of colour between theſe two extremes †.

† *Hauy, Jour. de Min.* N° xxviii, 272.

According to the analyſis of Vauquelin, it is compoſed of

50.0	ſilica,
13.0	lime,
11.0	alumina,
7.5	oxyd of chromum.
6.0	magneſia,
5.5	oxyd of iron,
1.5	oxyd of copper.
94.5 ‡	

‡ *Ann. de Chim.* xxx. 106.

GENUS XVII. SM.

SPECIES I. Kiffekil*.

Myrſen—Seafroth.

81
G. XVII.
SM.
Kiffekil.

* *Kirwan's Min.* i. 144.

This mineral is dug up near Konie in Natolia, and is employed in forming the bowls of Turkiſh tobacco pipes. The ſale of it ſupports a large monaſtery of derviſes eſtabliſhed near the place where it is dug. It is found in a large fiſſure ſix feet wide, in grey calcareous earth. The workmen aſſert, that it grows again in the fiſſure†, and puffs itſelf up like froth (E). This mineral, when freſh dug, is of the conſiſtence of wax; it feels ſoft and greaſy; its colour is yellow; its ſp. gr. 1.600 ‡: when thrown on the fire it ſweats, emits a fetid vapour, becomes hard, and perfectly white.

† *Reignegg. Philoſ. Mag.* iii. 165.
‡ *Klaproth.*

According to the analyſis of Klaproth, it is compoſed of

50.50	ſilica,
17.25	magneſia,
25.00	water,
5.00	carbonic acid,
.50	lime.
98.25 §	

§ *Beiträge*, ii 171.

SPECIES 2. Steatites (F).

82
Steatites.

Though this mineral was noticed by the ancients, little attention was paid to it by mineralogiſts, till Mr Pott publiſhed his experiments on it in the Berlin Memoirs for 1747.

It is uſually amorphous, but ſometimes it is cryſtallized in ſix-ſided priſms. Its texture is commonly earthy, but ſometimes foliated. Luſtre from 0 to 2. Tranſparency from 0 to 2. Hardneſs 4 to 7. Sp. gr. from 2.61 to 2.794*. Feels greaſy. Seldom adheres to the tongue. Colour uſually white or grey; often with a tint of other colours; the foliated commonly green. Does not melt *per ſe* before the blow-pipe.

* *Briſſon.*

Simple Stones.

Variety 1. Semi-indurated ſteatites.

Texture earthy. Fracture ſometimes coarſe ſplintery. Luſtre 0. Tranſparency 0, or ſcarce 1. Hardneſs 4 to 5. Abſorbs water. Takes a poliſh from the nail. Colour white, with a ſhade of grey, yellow, or green; ſometimes pure white; ſometimes it contains dendritical figures; and ſometimes red veins.

Variety 2. Indurated ſteatites.

Fracture fine ſplintery, often mixed with imperfectly conchoidal. External luſtre 2 to 1, internal 0. Tranſparency 2. Often has the feel of ſoap. Abſorbs water. Colour yellowiſh or greeniſh grey; often veined or ſpotted with deep yellow or red.

Variety 3. Foliated or ſtriated ſteatites.

The texture of this variety is uſually foliated; ſometimes ſtriated. Fragments cubiform. Luſtre 3. Tranſparency 2 to 1. Hardneſs 6 to 7. Colour leek green, paſſing into mountain green or ſulphur yellow. Streak pale greeniſh grey. When heated to redneſs, it becomes grey; and at 147° Wedgewood, it forms a grey porous porcelain maſs*.

* *Kirwan*, i. 155.

A ſpecimen of ſteatites, analyſed by Klaproth, contained

59.5	ſilica,
30.5	magneſia,
2.5	iron,
5.5	water,
98.0 †	

† *Beiträge*, ii. 179.

A ſpecimen of white ſteatites, analyſed by Mr Chenevix, contained

60.00	ſilica,
28.50	magneſia,
3.00	alumina,
2.50	lime,
2.25	iron.
96.25 ‡	

‡ *Ann. de Chim.* xxviii. 200.

GENUS XVIII. MSI.

SPECIES I. Chryſolite (G).

Peridot of the French—*Topaz* of the ancients.

83
G. XVIII.
MSI.
Chryſolite.

The name *chryſolite* was applied, without diſcrimination, to a great variety of ſtones, till Werner defined it accurately, and confined it to that ſtone which the French chemiſts diſtinguiſh by the appellation of *peridot*. This ſtone is the *topaz* of the ancients; their chryſolite is now called *topaz* §.

§ *Plinii*, lib. 37. c. 8.

Chryſolite is found ſometimes in unequal fragments, and ſometimes cryſtallized †. The primitive form of its cryſtals is a right angled parallelopiped ‡, whoſe length, breadth, and thickneſs, are as 5, √8, √5*.

† Fig. 23.
‡ Fig. 24.

The texture of the chryſolite is foliated. Its fracture conchoidal. Its internal luſtre from 2 to 4. Its tranſparency from 4 to 2. Cauſes double refraction.

* *Hauy, Jour. de Min.* N° xxviii. 281.

The carbonat of lime was only mechanically interpoſed between the fibres of the ſtone. See *Pallas, Neu. Nord. Beiträge*, 6 *Band*, p. 146.

(E) Hence the name *kiff-kil*, or rather *keff-kelli*, "clay froth," or "light clay."

(F) *Kirw.* I. 151.—*Pott, Mem. Berlin*, 1747, p. 57.—*Wiegleb, Jour. de Phyſ.* XXIX. 60.—*Lavoiſier, Mem. Par.* 1778, 433.

(G) *Kirw.* I, 262.—*Cartheuſer, Min.* 94.—*Dolomieu, Jour. de Min.* N° xxix. 365.—*La Metherie, Nouv. Jour. de Phyſ.* I. 397.

Hardneſs 9 to 10. Brittle. Sp. gr. from 3.265 to 3.45. Colour green. It is infuſible at 150°, but loſes its tranſparency, and becomes blackiſh grey†. With borax it melts without effervеſcence into a tranſparent glaſs of a light green colour. Infuſible with microcoſmic ſalt ‡ and fixed alkali §.

Variety 1. Common chryſolite.

Found in Ceylon, and South America, and in Bohemia, amidſt ſand and gravel ‖. Luſtre 3 to 4. Tranſparency 4 to 3. Colour yellowiſh green, ſometimes verging to olive green, ſometimes to pale yellow.

Variety 2. Olive chryſolite—*Olivine* ¶,

Found commonly among traps and baſalts; ſometimes in ſmall grains, ſometimes in pretty large pieces; but it has not been obſerved in cryſtals. Luſtre 2 to 3. Tranſparency 3 to 2. Colour olive green.

The firſt variety, according to the analyſis of Klaproth, is compoſed of 41.5 magneſia,
38.5 ſilica,
19.0 oxyd of iron.

99.0†

According to that of Vauquelin, it is compoſed of
51.5 magneſia,
38.0 ſilica,
9.5 oxyd of iron.

99.0‡

The ſecond variety, according to the analyſis of Klaproth, is compoſed of 37.58 magneſia,
50.00 ſilica,
11.75 oxyd of iron,
.21 lime.

99.54 §.

84
Jade.

SPECIES 2. Jade (H).

This ſtone was formerly called *lapis niphriticus*, and was much celebrated for its medical virtues. It is found in Egypt, China, America, and in the Siberian and Hungarian mountains. It is ſometimes adhering to rocks, and ſometimes in detached round pieces.

Its ſurface is ſmooth. Its fracture ſplintery. External luſtre 0, or ſcarce 1; internal waxy, 1. Tranſparency from 2 to 1. Hardneſs 10. Not brittle. Sp. gr. from 2.95 to 2.9829; or, according to Sauſſure, to 3.389. Feels greaſy. Looks as if it had imbibed oil. Colour dark leek green, or verging towards blue; in ſome prominencies inclining to greeniſh or bluiſh white. When heated it becomes more tranſparent and brittle, but is infuſible *per ſe*. According to Hœpſner, it is compoſed of 47 ſilica,
38 carbonat of magneſia,
9 iron,
4 alumina,
2 carbonat of lime,

100

This is the ſtone which the inhabitants of New Zealand make into hatchets and other cutting inſtruments.

85
G XIX. SML.
Aſbeſtus.

GENUS XIX. SML.

SPECIES 1. Aſbeſtus (I).

This mineral was well known to the ancients. They even made a kind of cloth from one of the varieties, which was famous among them for its incombuſtibility. It is found abundantly in moſt mountainous countries, and no where more abundantly than in Scotland.

It is commonly amorphous. Its texture is fibrous. Its fragments often long ſplintery. Luſtre from 0 to 2; ſometimes 3, and then it is metallic. Tranſparency from 0 to 2. Hardneſs from 3 to 7. Sp. gr. from 2.7 to 0.6806. Abſorbs water. Colour uſually white or green. Fuſible *per ſe* by the blow-pipe.

Variety 1. Common aſbeſtus.

Luſtre 2 to 1. Tranſparency 1. Hardneſs 6 to 7. Sp. gr. 2.577 to 2.7. Feels ſomewhat greaſy. Colour leek green; ſometimes olive or mountain green; ſometimes greeniſh or yellowiſh grey. Streak grey. Powder grey.

Variety 2. Flexible aſbeſtus.

Amiantus.

Compoſed of a bundle of threads ſlightly cohering. Fibres flexible. Luſtre 1 to 2, ſometimes 3. Tranſparency 1 to 2, ſometimes 0. Hardneſs 3 to 4. Sp. gr. before it abſorbs water, from 0.9088 to 2.3134; after abſorbing water, from 1.5662 to 2.3803†. Feels greaſy. Colour greyiſh or greeniſh white; ſometimes yellowiſh or ſilvery white, olive or mountain green, pale fleſh red, and mountain yellow.

Variety 3. Elaſtic aſbeſtus.

Mountain cork.

This variety has a ſtrong reſemblance to common cork. Its fibres are interwoven. Luſtre commonly 0. Opaque. Hardneſs 4. Sp. gr. before abſorbing water, from 0.6806 to 0.9933; after abſorbing water, from 1.2492 to 1.3492. Feels meagre. Yields to the fingers like cork, and is ſomewhat elaſtic. Colour white; ſometimes with a ſhade of red or yellow; ſometimes yellow or brown.

A ſpecimen of the firſt variety from Dalecarlia, analyſed by Bergman, contained
63.9 ſilica,
16.0 carbonat of magneſia,
12.8 carbonat of lime,
6.0 oxyd of iron,
1.1 alumina.

99.8*

A ſpecimen of the ſecond variety yielded to the ſame chemiſt 64.0 ſilica,
17.2 carbonat of magneſia,
13.9 carbonat of lime,
2.7 alumina,
2.2 oxyd of iron.

100.0‡

A ſpecimen of the third variety contained, according to the ſame analyſis, 56.2 ſilica,
26.1 carbonat of magneſia,
12.7 carbonat of lime,
3.0 iron,
2.0 alumina.

100.0‖

Twelve

† Kir. Min. i. 263.

‡ Vauquelin, Ann. de Chim. xxi. 97.

§ Kirw. ibid.

‖ Coquebert, Jour. de Min. N° xxii. 20.

¶ Kirwan's Min. i. 263.—Le Lievre, Jour. de Phyſ. xxx. 397.

† Klaproth's Beiträge, i. 103.

‡ Ann. de Chim. ibid.

§ Beiträge, i. 112.

† Biſon.

* Opuſc. iv. 170.

‡ Ibid. p. 163.

‖ Ibid. p. 170.

(H) *Kirw.* I. 171.—*Bartolin, De Lapide Nephritico.*—*Lehmann, Nov. Comm. Petropol.* X. 381.—*Hœpfner, Hiſt. Nat. de la Suiſſe*, I. 251.

(I) *Kirw.* I. 159.—*Bergman*, IV. 160.—*Plot, Phil. Tranſ.* XV. 1051.—*Nebel, Jour. de Phyſ.* II. 62.—*Ibid.* III. 367.

Twelve different ſpecimens of aſbeſtus, analyſed by Bergman, yielded the ſame ingredients, differing a little in their proportions [†].

[†] Opuſc. iv. 175.

86 Aſbeſtinite.

SPECIES 2. Aſbeſtinite (K)

This ſtone is amorphous. Texture foliated or broad ſtriated. Luſtre ſilky, 3. Tranſparency 1 to 2. Hardneſs 5 to 6. Sp. gr. from 2.806 to 2.880. Colour white, with ſhades of red, yellow, green, or blue. At 150° Wedgewood it melts into a green glaſs.

87 G. XX. 1. SILM. Pyroxen.

GENUS XX. 1. SILM.

SPECIES 1. Pyroxen.

This ſtone is found abundantly in lava and other volcanic productions (L). It is always cryſtallized. The primitive form of its cryſtals is an oblique angled priſm, whoſe baſes are rhombs with angles of 92° 18′, and 37° 42′ [‡]. It generally cryſtallizes in eight ſided priſms, terminated by dihedral ſummits [‖]. Its texture is foliated. Hardneſs 9. Colour black; ſometimes green. Powder greeniſh grey [*]. Commonly attracted by the magnet [†]. Scarcely fuſible by the blow pipe [‡]. With borax it melts into a yellowiſh glaſs, which appears red while it is hot [§].

[‡] Hauy, Jour. de Min. No xxviii. 269.
[‖] De Liſle, ii. 398.
[*] Vauquelin.
[†] Ferber.
[‡] Le Lievre.
[§] Vauquelin.

According to the analyſis of Vauquelin, it is compoſed of

52.00	ſilica,
14.66	oxyd of iron,
13.20	lime,
10.00	magneſia,
3.33	alumina,
2.00	oxyd of mangeneſe.
95.19 [‖]	

[‖] Jour. de Min No xxix. 172.

88 Aſbeſtoid.

SPECIES 2. Aſbeſtoid [*].

This ſtone has obtained its name from its ſimilarity to common aſbeſtus. It is amorphous. Its texture is foliated or ſtriated. Its luſtre common or glaſſy, from 2 to 3. Tranſparency from 0 to 1. Hardneſs 6 to 7. Sp. gr. from 3 to 3.31. Colour olive or leek green; when decompoſing, brown. Before the blowpipe it melts *per ſe* into a brown globule. With borax it forms a violet coloured globule verging towards hyacinth [†]. According to the analyſis of Mr Macquart, it is compoſed of

46	ſilica,
20	oxyd of iron,
11	lime,
10	oxyd of mangeneſe,
8	magneſia.
95 [‡]	

[*] Kirwan, i. 166.
[†] Macquart, Ann. de Chim. xxii. 83.
[‡] Ibid.

There is a variety of this ſpecies which Kirwan calls metalliform aſbeſtoid. Its luſtre is ſemimetallic, 3. Opaque. Hardneſs 8 to 9. Sp. gr. 3.356. Colour grey, ſometimes inclining to red [*].

[*] Kirwan's Min. i. 167.

89 G. XX. 2. SMIL. Shorlaceous actinolite.

GENUS XX. 2. SMIL.

SPECIES 3. Shorlaceous actinolite (M).

This ſtone cryſtallizes in four or ſix ſided priſms, thicker at one end than the other; hence it has been called by the Germans *ſtrahlſtein*, "arrow-ſtone." The cryſtals ſometimes adhere longitudinally. Fracture hackly. External luſtre glaſſy, 3 to 4; internal, 1 to 2. Tranſparency from 2 to 3; ſometimes 1. Hardneſs from 7 to 10. Sp. gr. 3.023 to 3.45. Colour leek or dark green.

This ſtone is often the matrix of iron, copper, and tin ores.

90 Lamellar actinolite.

SPECIES 5. Lamellar actinolite.

This ſtone reſembles hornblende. It is amorphous. Texture foliated. Luſtre various in different places. Tranſparency 0, or ſcarce 1. Sp. gr. 2.916. Colour dark yellowiſh or greeniſh grey.

91 Glaſſy actinolite.

SPECIES 6. Glaſſy actinolite.

This ſtone is found amorphous, compoſed of fibres adhering longitudinally, or in ſlender four or ſix ſided priſms. Texture fibrous. Fragments long ſplintery, ſo ſharp that they can ſcarcely be handled without injury. External luſtre glaſſy or ſilky, 3 to 4; internal 0. Tranſparency 2. Exceedingly brittle. Sp. gr. 2.95 to 3.493. Colour leek green; ſometimes verging towards greeniſh or ſilver white; ſometimes ſtained with yellowiſh or browniſh red. According to Bergman it is compoſed of

72.0	ſilica,
12.7	carbonat of magneſia,
6.0	carbonat of lime,
7.0	oxyd of iron,
2.0	alumina.
99.7 [*]	

[*] Opuſc. iv. 171.

92 G. XXI. SL. Shiſtoſe hornſtone.

GENUS XXI. SL.

SPECIES 1. Shiſtoſe hornſtone [†].

The ſtructure of this ſtone is ſlaty. Luſtre from 0 to 1. Commonly opaque. Hardneſs 9 to 10. Sp. gr. from 2.596 to 2.641. Colour dark bluiſh or blackiſh grey. Infuſible *per ſe*.

[†] Kirwan, i. 305.

Variety 1. Siliceous ſhiſtus.

Commonly interſected by reddiſh veins of iron ſtone. Fracture ſplintery. Luſtre 0. Tranſparency from 0 to 1.

Variety 2. Baſanite or Lydian ſtone.

Commonly interſected by veins of quartz. Fracture even; ſometimes inclining to conchoidal. Luſtre ſcarce 1. Hardneſs 10. Sp. gr. 2.596. Powder black. Colour greyiſh black.

This, or a ſtone ſimilar to it, was uſed by the ancients as a touchſtone. They drew the metal to be examined along the ſtone, and judged of its purity by

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(K) *Kirw. Min.* I. 165. Is this the *tremolite* of Werner? It certainly is not the *tremolite* of the French mineralogiſts.

(L) Hence the name *pyroxen* given it by Hauy; from πυρ *fire*, and ξενος, *a ſtranger*. It means, as he himſelf explains it, a *ſtranger in the regions of fire*. By this he means to indicate, that pyroxen, though preſent in lava, is not a volcanic production.

(M) In this and the following ſpecies we have followed Mr Kirwan's new arrangement exactly, without even venturing to give the ſynonimes of other authors. The deſcriptions which have been given are ſo many and incomplete, and the minerals themſelves are ſtill ſo imperfectly known, and have got ſo many names, that no part of mineralogy is in a ſtate of greater confuſion.

the colour of the metallic ſtreak. On this account they called it *βασανος, the trier*. They called it alſo *Lydian ſtone*, becauſe, as Theophraſtus informs us, it was found moſt abundantly in the river Tmolus in Lydia†.

† Hill's *Theophraſtus, περι λιθων*, p. 190.

A ſpecimen of the firſt variety, analyſed by Wiegleb, contained 75.0 ſilica,
10.0 lime,
4.6 magneſia,
3.5 iron,
5.2 carbon.

98.3

This ſpecies is rather a mechanical mixture than a chemical combination.

93
G. XXII. 25.
Zircon.

GENUS XXII. 25.

SPECIES 1. Zircon*.

Jargon—Hyacinth.

* *Kirwan*, i. 257. and 333.

This ſtone is brought from Ceylon, and found alſo in France, Spain, and other parts of Europe. It is commonly cryſtallized. The primitive form of its cryſtals is an octahedron§, compoſed of two four ſided pyramids applied baſe to baſe, whoſe ſides are iſoſceles triangles (N). The inclination of the ſides of the ſame pyramid to each other is 124° 12′; the inclination of the ſides of one pyramid to thoſe of another 82° 50′. The ſolid angle at the apex is 73° 44′†. The varieties of the cryſtalline forms of zircon amount to ſeven. In ſome caſes there is a four ſided priſm interpoſed between the pyramids of the primitive form; ſometimes all the angles of this priſm are wanting, and two ſmall triangular faces in place of each; ſometimes the cryſtals are dodecahedrons, compoſed of a flat four-ſided priſm with hexagonal faces, terminated by four ſided ſummits with rhomboidal faces‖; ſometimes the edges of this priſm, ſometimes the edges where the priſm and ſummit join, and ſometimes both together, are wanting, and we find ſmall faces in their place. For an accurate deſcription and figure of theſe varieties, we refer to *Mr Haüy*‡.

§ Fig. 25.
† *Haüy*. *Jour. de Min.* N° xxvi. 91.
‖ Fig. 26.
‡ *Ibid.*

The texture of the zircon is foliated. Internal luſtre 3. Tranſparency from 4 to 2. Cauſes a very great double refraction. Hardneſs from 10 to 16. Sp. gr. from 4.2 to 4.165†. Colour commonly reddiſh or yellowiſh; ſometimes it is limpid.

† *Ibid.*

Before the blow-pipe it loſes its colour, but not its tranſparency. With borax it melts into a tranſparent glaſs. Infuſible with fixed alkali and microcoſmic ſalt.

1. The variety formerly called *hyacinth* is of a yellowiſh red colour, mixed with brown. Its ſurface is ſmooth. Its luſtre 3. Its tranſparency 3 to 4.

2. The variety formerly called *jargon of Ceylon*, is either grey, greeniſh, yellowiſh brown, reddiſh brown, or violet. It has little external luſtre. Is ſometimes nearly opaque.

The firſt variety, according to the analyſis of Vauquelin, is compoſed of 64.5 zirconia,
32.0 ſilica,
2.0 oxyd of iron.

98.5†

† *Ibid*. p. 106.

A ſpecimen analyſed by Klaproth contained
70.0 zirconia,
25.0 ſilica,
0.5 oxyd of iron.

95.5‡

‡ *Beitrage*, i. 231.

The ſecond variety, according to Klaproth, who diſcovered the component parts of both theſe ſtones, contains 68.0 zirconia,
31.5 ſilica,
0.5 nickel and iron.

100.0§

§ *Ibid*. i. 219.

ORDER II. SALINE STONES.

94
Genera.

UNDER this order we comprehend all the minerals which conſiſt of an earthy baſis combined with an acid. They naturally divide themſelves into five genera. We ſhall deſcribe them in the following order.

I. CALCAREOUS SALTS.
  Carbonat of lime,
  Sulphat of lime,
  Phoſphat of lime,
  Fluat of lime,
  Borat of lime.

II. BARYTIC SALTS.
  Carbonat of barytes,
  Sulphat of barytes.

III. STRONTITIC SALTS.
  Carbonat of ſtrontites,
  Sulphat of ſtrontites.

IV. MAGNESIAN SALTS.
  Sulphat of magneſia.

V. ALUMINOUS SALTS.
  Alum.

95
G. I. Calcareous ſalts.

GENUS I. CALCAREOUS SALTS.

This genus comprehends all the combinations of lime and acids which form a part of the mineral kingdom.

96
Carbonat of lime.

SPECIES 1. Carbonat of lime.

No other mineral can be compared with carbonat of lime in the abundance with which it is ſcattered over the earth. Many mountains conſiſt of it entirely, and hardly a country is to be found on the face of the globe where, under the names of limeſtone, chalk, marble, ſpar, it does not conſtitute a greater or ſmaller part of the mineral riches.

It is often amorphous, often ſtalactitical, and often cryſtallized. The primitive form of its cryſtals is a parallelopiped, whoſe ſides are rhombs, with angles of 77° 30′ and 102° 30′‡. Its integrant molecules have the ſame form. The varieties of its cryſtals amount to more than 40; for a deſcription and figure of which we refer to *Romé de Liſle** and *Haüy* (O).

‡ Fig. 28.
* *Cryſtal*. i. 497.

When cryſtallized, its texture is foliated; when amorphous, its ſtructure is ſometimes foliated, ſometimes ſtriated, ſometimes granular, and ſometimes earthy. Its luſtre

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(N) Let ABC (fig. 27.) be one of the ſides. Draw the perpendicular BD; then AB = 5, BD = 4, AD = 3.

(O) *Eſſai d une Theorie*, &c. p. 75.—*Jour. de Phyſ.* 1793, Auguſt, p. 114.—*Jour. d'Hiſt. Nat.* 1792, February, p. 148.—*Ann. de Chim.* XVII. 249. &c.—*Jour de Min.* N° XXVIII. 304.

Earths and Stones.

luſtre varies from 0 to 3. Tranſparency from 0 to 4. It cauſes double refraction; and it is the only mineral which cauſes double refraction through two parallel faces of the cryſtal. Hardneſs from 3 to 9. Sp. gr. from 2.315 to 2.78. Colour, when pure, white. Effervеſces violently with muriatic acid, and diſſolves completely, or leaves but a ſmall reſiduum. The ſolution is colourleſs.

This ſpecies occurs in a great variety of forms; and therefore has been ſubdivided into numerous varieties. All theſe may be conveniently arranged under two general diviſions.

I. Soft carbonat of lime.

Variety 1. Agaric mineral.

Mountain milk, or *mountain meal* of the Germans.

This variety is found in the clefts of rocks, or the bottom of lakes. It is nearly in the ſtate of powder; of a white colour, ſometimes with a ſhade of yellow; and ſo light, that it almoſt floats on water.

Variety 2. Chalk.

The colour of chalk is white, ſometimes with a ſhade of yellow. Luſtre 0. Opaque. Hardneſs 3 to 4. Sp. gr. from 2.315 to 2.657. Texture earthy. Adheres ſlightly to the tongue. Feels dry. Stains the fingers, and marks. Falls to powder in water. It generally contains about $\frac{2}{100}$ of alumina, and $\frac{3}{100}$ of water; the reſt is carbonat of lime.

Variety 3. Arenaceous limeſtone.

Colour yellowiſh white. Luſtre 1. Tranſparency 1. So brittle, that ſmall pieces crumble to powder between the fingers. Sp. gr. 2.742. Phoſphoreſces in the dark when ſcraped with a knife, but not when heated. It conſiſts almoſt entirely of pure carbonat of lime.

Variety 4. Teſtaceous tufa.

The colour of this variety is yellowiſh or greyiſh white. It is exceedingly porous and brittle; and is either compoſed of broken ſhells, or reſembles mortar containing ſhells; or it conſiſts of fiſtulous concretions varioſly ramified, and reſembling moſs.

II. Indurated carbonat of lime.

Variety 1. Compact limeſtone.

The texture of this variety is compact. It has little luſtre; and is moſt commonly opaque. Hardneſs 5 to 8. Sp. gr. 1.3864 to 2.72. Colour grey, with various ſhades of other colours. It moſt commonly contains about $\frac{1}{10}$th of alumina, oxyd of iron, &c.; the reſt is carbonat of lime. This variety is uſually burnt as lime.

Variety 2. Granularly foliated limeſtone.

Structure ſometimes ſlaty. Texture foliated and granular. Luſtre 2 to 1. Tranſparency 2 to 1. Hardneſs 7 to 8. Sp. gr. 2.71 to 2.8376. Colour white, of various ſhades from other colours.

Variety 3. Sparry limeſtone.

Structure ſparry. Texture foliated. Fragments rhomboidal. Luſtre 2 to 3. Tranſparency from 2 to 4; ſometimes 1. Hardneſs 5 to 6. Sp. gr. from 2.693 to 2.718. Colour white: often with various ſhades of other colours. To this variety belong all the cryſtals of carbonat of lime.

Variety 4. Striated limeſtone.

Texture ſtriated or fibrous. Luſtre 1 to 0. Tranſparency 2 to 1. Hardneſs 5 to 7. Sp. gr. commonly from 2.6 to 2.77. Colours various.

Variety 5. Swine ſtone.

Saline Stones.

Texture often earthy. Fracture often ſplintery. Luſtre 1 to 0. Tranſparency 0 to 1. Hardneſs 6 to 7. Sp. gr. 2.701 to 2.7121. Colour dark grey, of various ſhades. When ſcraped or pounded, it emits an urinous or garlic ſmell.

Variety 6. Oviform.

This variety conſiſts of a number of ſmall round bodies, cloſely compacted together. Luſtre 0. Tranſparency 0 or 1. Hardneſs 6 to 7.

97
Sulphat of lime.

SPECIES 2. Sulphat of lime.

Gypſum—Selenite.

This mineral is found abundantly in Germany, France, England, Italy, &c.

It is found ſometimes in amorphous maſſes, ſometimes in powder, and ſometimes cryſtallized. The primitive form of its cryſtals, according to Romé de Liſle, is a decahedron ‡, which may be conceived as two four-ſided pyramids, applied baſe to baſe, and which, inſtead of terminating in pointed ſummits, are truncated near their baſes; ſo that the ſides of the pyramids are trapeziums, and they terminate each in a rhomb. Theſe rhombs are the largeſt faces of the cryſtal. The angles of the rhombs are 52° and 158°. The inclination of two oppoſite faces of one pyramid to the two ſimilar faces of the other pyramid is 145°, that of the other faces 110° *. Sometimes ſome of the faces are elongated: ſometimes it cryſtalliſes in ſix-ſided priſms, terminated by three or four ſided ſummits, or by an indeterminate number of curvilinear faces. For a deſcription and figure of theſe varieties, we refer to *Romé de Liſle* †.

‡ Fig. 29.

* *Cryſtal.* i. 144.

† *Ibid.*

The texture of ſulphat of lime is moſt commonly foliated. Luſtre from 0 to 4. Tranſparency from 0 to 4. It cauſes double refraction. Its hardneſs does not exceed 4. Its ſp. gr. from 1.872 to 2.311. Colour commonly white or grey.

Before the blow-pipe, it melts into a white enamel, provided the blue flame be made to play upon the edges of its laminæ. When the flame is directed againſt its faces, the mineral falls into powder ‡.

‡ *Le Lievre, Jour. de Min.* Nº xxviii. 315.

It does not effervеſce with muriatic acid, except it be impure; and it does not diſſolve in it.

The following varieties of this mineral are deſerving of attention.

Variety 1. Broad foliated ſulphat.

Texture broad foliated. Luſtre glaſſy; from 4 to 2. Tranſparency from 4 to 3. Hardneſs 4. Sp. gr. 2.311. Colour grey, often with a ſhade of yellow.

Variety 2. Grano-foliated ſulphat.

Texture foliated, and at the ſame time granular; ſo that it eaſily crumbles into powder. Luſtre 2 to 3. Tranſparency 2 to 3. Hardneſs 4 to 3. Sp. gr. from 2.274 to 2.310. Feels ſoft. Colour white or grey, often with a tinge of yellow, blue, or green; ſometimes fleſh red, brown, or olive green.

Variety 3. Fibrous ſulphat.

Texture fibrous. Fragments long ſplintery. Luſtre 2 to 3. Tranſparency 2 to 1; ſometimes 3. Hardneſs 4. Brittle. Sp. gr. 2.300. Colour white, often with a ſhade of grey, yellow, or red; ſometimes fleſh red, and ſometimes honey yellow; ſometimes ſeveral of theſe colours meet in ſtripes.

Variety 4. Compact ſulphat.

Texture compact. Luſtre 1 or 0. Tranſparency 2 to 1.

1, ſometimes 0. Hardneſs 4. Sp. gr. from 1.872 to 2.288. Feels dry, but not harſh. Colour white, with a ſhade of grey, yellow, blue, or green; ſometimes yellow; ſometimes red; ſometimes ſpotted, ſtriped, or veined.

Variety 5. Farinaceous ſulphat.

Of the conſiſtence of meal. Luſtre 0. Opaque. Scarcely ſinks in water. Is not gritty between the teeth. Feels dry and meagre. Colour white. When heated below redneſs, it becomes of a dazzling white.

98 Phoſphat of lime.

SPECIES 3. Phoſphat of lime.

Apatite—Phoſphorite—Chryſolite—of the French.

This ſubſtance is found in Spain, where it forms whole mountains, and in different parts of Germany. It is ſometimes amorphous, and ſometimes cryſtallized. The primitive form of its cryſtals is a regular ſix-ſided priſm ‡. Its integrant molecule is a regular triangular priſm, whoſe height is to a ſide of its baſe as 1 to √2 §. Sometimes the edges of the primitive hexagonal priſm are wanting, and ſmall faces in their place; ſometimes there are ſmall faces inſtead of the edges which terminate the priſm; ſometimes theſe two varieties are united; ſometimes the terminating edges and the angles of the priſm are replaced by ſmall faces †; and ſometimes the priſm is terminated by four-ſided pyramids *.

‡ Fig. 30.

§ *Hauy, Jour. de Min.* N° xxviii. p. 310.

† Fig. 31.

* *Hauy, ibid.*

Its texture is foliated. Its fracture uneven, tending to conchoidal. External luſtre from 2 to 3, internal 3 to 2. Tranſparency from 4 to 2. Cauſes ſingle refraction. Hardneſs 6 to 7. Brittle. Sp. gr. from 2.8249 to 3.218. Colour commonly green or grey; ſometimes brown, red, blue, and even purple.

It is infuſible by the blow-pipe. When its powder is thrown upon burning coals, it emits a yellowiſh green phoſphoreſcent light. It is ſoluble in muriatic acid without effervеſcence or decompoſition, and the ſolution often becomes gelatinous.

99 Fluat of lime.

SPECIES 4. Fluat of lime.

Fluor.

This mineral is found abundantly in different countries, particularly in Derbyſhire. It is both amorphous and cryſtallized.

The primitive form of its cryſtals is the regular octohedron; that of its integrant molecules the regular tetrahedron *. The varieties of its cryſtals hitherto obſerved amount to 7. Theſe are the primitive octohedron; the cube; the rhomboidal dodecahedron; the cubo octohedron †, which has both the faces of the cube and of the octohedron; the octohedron wanting the edges; the cube wanting the edges, and either one face ‡, or two faces in place of each. For a deſcription and figure of theſe we refer to *Mr Hauy* †.

* *Hauy, ibid.* p. 325.

† Fig. 32.

‡ Fig. 33.

† *Ibid.*

The texture of fluat of lime is foliated. Luſtre from 2 to 3, ſometimes 0. Tranſparency from 2 to 4, ſometimes 1. Cauſes ſingle refraction. Hardneſs 8. Very brittle. Sp gr. from 3.0943 to 3.1911. Colours numerous, red, violet, green, red yellow, blackiſh purple. Its powder thrown upon hot coals emits a bluiſh or greeniſh light. Two pieces of it rubbed in the dark phoſphoreſce. It decrepitates when heated. Before the blow-pipe it melts into a tranſparent glaſs ‡.

‡ *Ibid.*

It admits of a poliſh, and is often formed into vaſes and other ornaments.

100 Borat of lime.

SPECIES 5. Borat of lime.

Boracite.

This mineral has been found at Kalkberg near Luneburg, ſeated in a bed of ſulphat of lime. It is cryſtallized. The primitive form of its cryſtals is the cube §. In general, all the edges and angles of the cube are truncated; ſometimes, however, only the alternate angles are truncated *. The ſize of the cryſtals does not exceed half an inch.

§ *Hauy, Jour. de Min.* N° xxviii p. 325.

* *Hauy and Weſtrum.*

The texture of this mineral is compact. Its fracture is flat conchoidal. External luſtre 3; internal, greaſy, 2. Tranſparency from 2 to 3. Hardneſs 9 to 10. Sp. gr. 2.566. Colour greyiſh white, ſometimes paſſing into greeniſh white or purpliſh.

When heated it becomes electric; and the angles of the cube are alternately poſitive and negative †.

Before the blow-pipe it froths, emits a greeniſh light, and is converted into a yellowiſh enamel, garniſhed with ſmall points, which, if the heat be continued, dart out in ſparks ‖.

† *Hauy, ibid.* and *Ann. de Chim.* ix. 59.

‖ *Le Lievre, Jour. de Min. ibid.*

According to Weſtrum, who diſcovered its component parts, it contains 68 boracic acid,
13.5 magneſia,
11 lime,
1 alumina,
2 ſilica,
1 iron.

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96 §

§ *Ann. de Chim.* ii. 116.

101 Nitrat of lime.

SPECIES 6. Nitrat of lime.

Found abundantly mixed with native nitre. For a deſcription ſee the article CHEMISTRY in this *Supplement*, n° 672.

102 G II. Barytic ſalts.

GENUS II. BARYTIC SALTS.

This genus comprehends the combinations of barytes with acids.

103 Carbonat of barytes.

SPECIES 1. Carbonat of barytes.

Witherite.

This mineral was diſcovered by Dr Withering; hence Werner has given it the name of *witherite*. It is found both amorphous and cryſtallized. The cryſtals are octohedrons or dodecahedrons, conſiſting of four or ſix ſided pyramids applied baſe to baſe; ſometimes the ſix-ſided pyramids are ſeparated by a priſm; ſometimes ſeveral of theſe priſms are joined together in the form of a ſtar.

Its texture is fibrous. Its fracture conchoidal. Its fragments long ſplintery. Luſtre 2. Tranſparency 2 to 3. Hardneſs 5 to 6. Brittle. Sp. gr. 4.3 to 4.338. Colour greeniſh white. When heated it becomes opaque. Its powder phoſphoreſces when thrown on burning coals *.

* *Hauy.*

It is ſoluble with effervеſcence in muriatic acid. The ſolution is colourleſs.

According to Pelletier it contains
62 barytes,
22 carbonic acid,
16 water.

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100 †

† *Jour. de Min.* N° xxi. p. 46.

104 Sulphat of barytes.

SPECIES 2. Sulphat of barytes.

Baroſelenite.

This mineral is found abundantly in many countries, particularly in Britain. It is ſometimes in powder, often in amorphous maſſes, and often cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are rhombs, with angles of 101° 30′ and 78° 30′ ‡. The varieties of its cryſtals are very numerons. For a deſcription and figure of them we refer to *Romé de Liſle* ‖ and *Hauy* *. The moſt common varieties are the octohedron with cuneiform ſummits, the ſix or four ſided priſm, the hexangular table with bevelled edges. Sometimes theſe cryſtals are needle form.

Its texture is commonly foliated. Luſtre from 0 to 2. Tranſparency from 2 to 0; in ſome caſes 3 or 4. Hardneſs from 5 to 6. Sp. gr. from 4.4 to 4.44. Colour commonly white, with a ſhade of yellow, red, blue, or brown.

When heated it decrepitates. It is fuſible *per ſe* by the blue flame of the blow-pipe, and is converted into ſulphurat of barytes. Soluble in no acid except the ſulphuric; and precipitated from it by water.

Variety 1. Foliated ſulphat.

Luſtre 3 to 3. Tranſparency from 4 to 2, ſometimes 1. Colours white, reddiſh, bluiſh, yellowiſh, blackiſh, greeniſh. Mr Werner ſubdivides this variety into three, according to the nature of the texture. Theſe three ſubdiviſions are *granularly foliated*, *ſtraight foliated*, *curve foliated*.

Variety 2. Fibrous ſulphat.

Texture fibrous; fibres converging to a common centre. Luſtre ſilky or waxy, 2. Tranſparency 2 to 1. Hardneſs 5. Colours yellowiſh, bluiſh, reddiſh.

Variety 3. Compact ſulphat.

Texture compact. Luſtre 0 to 1. Tranſparency 1 to 0. Feels meagre. Almoſt conſtantly impure. Colours light yellow, red, or blue.

Variety 4. Earthy ſulphat.

In the form of coarſe duſty particles, ſlightly cohering. Colour reddiſh or yellowiſh white.

105 G. III. rontitic ts.

GENUS III. STRONTITIC SALTS.

This genus comprehends all the combinations of ſtrontites and acids which form a part of the mineral kingdom.

106 rbonat of ontites

SPECIES 1. Carbonat of ſtrontites.

This mineral was firſt diſcovered in the lead mine of Strontion in Argyleſhire; and ſince that time it is ſaid to have been diſcovered, though not in great abundance, in other countries. It is found amorphous, and alſo cryſtallized in needles, which, according to Hauy, are regular ſix ſided priſms.

Its texture is fibrous; the fibres converge. Fracture uneven. Luſtre 2. Tranſparency 2. Hardneſs 5. Sp. gr. from 3.4 to 3.66. Colour light green. Does not decrepitate when heated. Before the blow-pipe becomes opaque and white, but does not melt. With borax it effervesces, and melts into a tranſparent colourleſs glaſs. Effervesces with muriatic acid, and is totally diſſolved. The ſolution tinges flame purple.

107 hat of ntites.

SPECIES 2. Sulphat of ſtrontites.

Celeſtine.

This mineral has been found in Pennſylvania, in Germany, in France, in Sicily, and Britain. It was firſt diſcovered near Briſtol by Mr Clayfield. There it is found in ſuch abundance, that it has been employed in mending the roads.

It occurs both amorphous and cryſtallized. The cryſtals are moſt commonly bevelled tables, ſometimes rhomboidal cubes. Its texture is foliated. More or leſs tranſparent. Hardneſs 5. Sp. gr. from 3.51 to 3.96. Colour moſt commonly a fine ſky blue; ſometimes reddiſh; ſometimes white, or nearly colourleſs *.

Klaproth found a ſpecimen of this mineral from Pennſylvania compoſed of
58 ſtrontites,
42 ſulphuric acid.
—
100 †

According to the analyſis of Mr Clayfield, the ſulphat of ſtrontites found near Briſtol is compoſed of
58.25 ſtrontites,
41.75 ſulphuric acid of 2.24, and a little iron ‡.
—
100.00

According to the analyſis of Vauquelin, the ſulphat of ſtrontites found at Bouvron in France, which was contaminated with .1 of carbonat of lime, is compoſed of
54 ſtrontites,
45 ſulphuric acid.
—
99 §

GENUS IV. MAGNESIAN SALTS.

108 G IV. Magneſian Salts.

This genus comprehends the combinations of magneſia and acids which occur in the mineral kingdom. Only two ſpecies have hitherto been found; namely,

SPECIES 1. Sulphat of magneſia.

109 Sulphat of magneſia.

It is found in Spain, Bohemia, Britain, &c.; and enters into the compoſition of many mineral waters.

For a deſcription of it, we refer to CHEMISTRY, n° 633. in this *Suppl.*

SPECIES 2. Nitrat of magneſia.

110 Nitrat of magneſia.

Found ſometimes aſſociated with nitre. For a deſcription ſee CHEMISTRY, n° 674.

GENUS V. ALUMINOUS SALTS.

111 G. V. Aluminous ſalts.

This genus comprehends thoſe combinations of alumina and acids which occur in the mineral kingdom.

SPECIES 1. Alum.

112 Alum.

This ſalt is found in cryſtals, in ſoft maſſes, in flakes, and inviſibly mixed with the ſoil. For a deſcription, we refer to CHEMISTRY, n° 636.

ORDER III. AGGREGATES.

THIS order comprehends all mechanical mixtures of earths and ſtones found in the mineral kingdom. Theſe are exceedingly numerous: the mountains and hills, the mould on which vegetables grow, and indeed the greater part of the globe, may be conſidered as compoſed of them. A complete deſcription of aggregates belongs rather to geology than mineralogy. It would be improper, therefore, to treat of them fully here. But they cannot be altogether omitted; becauſe aggregates are the firſt ſubſtances which preſent themſelves to the view of the practical mineralogiſt, and becauſe, without being acquainted with the names and component parts of many of them, the moſt valuable mineralogical works could not be underſtood.

113 Diviſion of aggregates.

Aggregates may be comprehended under four diviſions: 1. Mixtures of earths; 2. Amorphous fragments of ſtones agglutinated together; 3. Cryſtallized ſtones, either agglutinated together or with amorphous ſtones; 4. Aggregates formed by fire. It will be exceedingly convenient to treat each of theſe ſeparately. We ſhall therefore divide this order into four ſections.

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‡ Hauy, Eſſai d'une Theorie, &c. p. 119.

‖ Cryſtal. i. 588.

* Ibid. and Ann de Chim xii. 3.

* Clayfield, Nicholſon's Jour. iii. 36.

† Beiträge, ii. 97.

‡ Ibid. Nicholſon's Journal.

§ Jour. de Min. N° xxxvii. 6.

Sect. I. *Aggregates of Earths.*

The moſt common earthy aggregates may be comprehended under the following genera:

1. Clay,
2. Colorific earths,
3. Marl,
4. Mould.

114 Clay.

Genus I. clay.

Clay is a mixture of alumina and ſilica in various proportions. The alumina is in a ſtate of an impalpable powder; but the ſilica is almoſt always in ſmall ſtones, large enough to be diſtinguiſhed by the eye. Clay, therefore, exhibits the character of alumina, and not of ſilica, even when this laſt ingredient predominates. The particles of ſilica are already combined with each other; and they have ſo ſtrong an affinity for each other, that few bodies can ſeparate them; whereas the alumina, not being combined, readily diſplays the characters which diſtinguiſh it from other bodies. Beſides alumina and ſilica, clay often contains carbonat of lime, of magneſia, barytes, oxyd of iron, &c. And as clay is merely a mechanical mixture, the proportion of its ingredients is exceedingly various.

Clay has been divided into the following ſpecies:

115 Porcelain clay.

species 1. Porcelain clay.

Its texture is earthy. Its luſtre 0. Opaque. Hardneſs 4. Sp. gr. from 2.23 to 2.4. Colour white, ſometimes with a ſhade of yellow or red. Adheres ſlightly to the tongue. Feels ſoft. Falls to powder in water.

A ſpecimen, analyſed by Haſſenfratz, contained

62 ſilica,
19 alumina,
12 magneſia,
7 ſulphat of barytes.

———

100 *

A ſpecimen, analyſed by Mr Wedgewood, contained

60 alumina,
20 ſilica,
12 air of water.

———

92

116 Common clay.

species 2. Common clay.

Its texture is earthy. Luſtre 0. Opaque. Hardneſs 3 to 6. Sp. gr. 1.8 to 2.68. Adheres ſlightly to the tongue. Often feels greaſy. Falls to powder in water. Colour, when pure, white; often tinged blue or yellow.

Variety 1. Potter's clay.

Hardneſs 3 to 4. Sp. gr. 1.8 to 2. Stains the fingers ſlightly. Acquires ſome poliſh by friction. Colour white; often with a tinge of yellow or blue; ſometimes browniſh, greeniſh, reddiſh. Totally diffuſible in water; and, when duly moiſtened, very ductile.

Variety 2. Indurated clay.

Hardneſs 5 to 6. Does not diffuſe itſelf in water; but falls to powder. Diſcovers but little ductility. Colours grey, yellowiſh, bluiſh, greeniſh, reddiſh, browniſh.

Variety 3. Shiſtoſe clay.

Structure ſlaty. Sp. gr. from 2.6 to 2.68. Feels ſmooth. Streak white or grey. Colour commonly bluiſh, or yellowiſh grey; ſometimes blackiſh, reddiſh, greeniſh. Found in ſtrata, uſually in coal mines.

This variety is ſometimes impregnated with bitumen. It is then called bituminous *ſhale.*

117 Lithomarga.

species 3. Lithomarga.

Texture earthy. Fracture conchoidal. Luſtre from 0 to 2. Opaque. Hardneſs 3 to 7. Sp. gr. when pretty hard, 2.815. Surface ſmooth, and feels ſoapy. Adheres ſtrongly to the tongue. Falls to pieces, and then to powder, in water; but does not diffuſe itſelf through that liquid. Fuſible *per ſe* into a frothy maſs.

Variety 1. Friable lithomarga.

Formed of ſcaly particles ſlightly cohering. Luſtre 1 to 0. Hardneſs 3 to 4. Exceedingly light. Feels very ſmooth, and aſſumes a poliſh from the nail. Colour white; ſometimes tinged yellow or red.

Variety 2. Indurated lithomarga.

Hardneſs 4 to 7. The ſofter ſorts adhere very ſtrongly to the tongue when newly broken; the harder very moderately. Colours grey, yellow, red, brown, blue.

A ſpecimen of lithomarga from Oſmund, analyſed by Bergman, contained

60.0 ſilica,
11.0 alumina,
5.7 carbonat of lime,
4.7 oxyd of iron,
0.5 carbonat of magneſia,
18.0 water and air.

———

99.9 †

118 Bole.

species 4. Bole.

Texture earthy. Fracture conchoidal. Luſtre 0. Tranſparency ſcarce 1. Hardneſs 4. Sp. gr. from 1.4 to 2. Acquires a poliſh by friction. Scarcely adheres to the tongue. Feels greaſy. Colour yellow or brown; ſometimes red; ſometimes ſpotted.

The lemnian earth which belongs to this ſpecies, according to the analyſis of Bergman, contains

47.0 ſilica,
19.0 alumina,
6.0 carbonat of magneſia,
5.4 carbonat of lime,
5.4 oxyd of iron,
17.0 water and air.

———

99.8 ‡

119 Fullers earth.

species 5. Fullers earth.

Texture earthy. Structure ſometimes ſlaty. Fracture imperfectly conchoidal. Luſtre 0. Opaque. Hardneſs 4. Receives a poliſh from friction. Does not adhere to the tongue. Feels greaſy. Colour uſually light green.

A ſpecimen from Hampſhire, analyſed by Bergman, contained

51.8 ſilica,
25.0 alumina,
3.3 carbonat of lime,
3.7 oxyd of iron,
0.7 carbonat of magneſia,
15.5 moiſture.

———

100.0 §

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* *Ann. de Chim.* xiv. 244.

† *Opuſc.* iv.

‡ *Ibid.* p. 157.

§ *Ibid.* 1

This earth is uſed by fullers to take the greaſe out of their cloth before they apply ſoap. It is eſſential to fullers earth that the particles of ſilica be very fine, otherwiſe they would cut the cloth. Any clay, poſſeſſed of this laſt property, may be conſidered as *fullers earth*; for it is the alumina alone which acts upon the cloth, on account of its ſtrong affinity for greaſy ſubſtances.

120 G. II. Colorific earths.

Genus II. Colorific Earths.

The minerals belonging to this genus conſiſt of clay, mixed with ſo large a quantity of ſome colouring ingredient as to render them uſeful as paints. The colouring matter is commonly oxyd of iron, and ſometimes charcoal.

121 Red chalk.

Species 1. Red chalk.

Reddle.

Texture earthy. Fracture conchoidal. Luſtre 0. Opaque. Hardneſs 4. Sp. gr. inconſiderable. Colour dark red.

Feels rough. Stains the fingers. Adheres to the tongue. Falls to powder in water. Does not become ductile. When heated it becomes black, and at 159° Wedgewood melts into a greeniſh yellow frothy enamel.

Compoſed of clay and oxyd of iron.

122 Yellow chalk.

Species 2. Yellow chalk.

Texture earthy. Fracture conchoidal. Hardneſs 3. Sp. gr inconſiderable. Colour ochre yellow.

Feels ſmooth or greaſy. Stains the fingers. Adheres to the tongue. Falls to pieces in water. When heated becomes red; and at 156° Wedgewood melts into a brown porous porcelain.

According to Sage, it contains

50 alumina,
40 oxyd of iron,
10 water, with ſome ſulphuric acid.
——
100 *

123 Black chalk.

Species 3. Black chalk.

Structure ſlaty. Texture earthy. Fragments ſplintery. Luſtre 0. Opaque. Hardneſs 5. Sp. gr. 2.144 to 2.277. Colour black. Streak black.

Feels ſmooth. Adheres ſlightly to the tongue. Does not moulder in water. When heated to redneſs it becomes reddiſh grey.

According to Wiegleb, it is compoſed of

64.50 ſilica,
11.25 alumina,
11.00 charcoal,
2.75 oxyd of iron,
7.50 water.
——
97.00 †

124 Green earth.

Species 4. Green earth.

Texture earthy. Luſtre 0. Opaque. Hardneſs 6 to 7. Sp gr. 2.637. Colour green.

Commonly feels ſmooth. Does not ſtain the fingers. Often falls to powder in water. When heated it becomes reddiſh brown; and at 147° Wedgewood melts into a black compact glaſs.

Compoſed of clay, oxyds of iron and nickel.

125 G. III. Marl.

Genus III. Marl.

A mixture of carbonat of lime and clay, in which the carbonat conſiderably exceeds the other ingredient, is called *marl*.

Its texture is earthy. Luſtre 0. Opaque. Hardneſs from 4 to 8; ſometimes in powder. Sp. gr. from 1.6 to 2.877. Colour uſually grey, often tinged with other colours. Efferveſces with acids.

Some marls crumble into powder when expoſed to the air; others retain their hardneſs for many years.

Marls may be divided into two ſpecies: 1. Thoſe which contain more ſilica than alumina; 2. Thoſe which contain more alumina than ſilica. Mr Kirwan has called the firſt of theſe *ſiliceous*, the ſecond *argillaceous*, marls. Attention ſhould be paid to this diſtinction when marls are uſed as a manure.

126 G. IV. Mould.

Genus IV. Mould.

By *mould* is meant the ſoil on which vegetables grow.

It contains the following ingredients: ſilica, alumina, lime, magneſia (ſometimes), iron, carbon derived from decayed vegetable and animal ſubſtances, carbonic acid, and water. And the good or bad qualities of *ſoils* depends upon a proper mixture of theſe ingredients. The ſilica is ſeldom in the ſtate of an impalpable powder, but in grains of a greater or ſmaller ſize: Its chief uſe ſeems to be to keep the ſoil open and pervious to moiſture. If we paſs over the carbon, the iron, and the carbonic acid, the goodneſs of a ſoil depends upon its being able to retain the quantity of moiſture which is proper for the nouriſhment of vegetables, and no more. Now the retentive power of a ſoil increaſes with the proportion of its alumina, lime, or magneſia, and diminiſhes as the proportion of its ſilica increaſes. Hence it follows, that in a dry country, a fertile ſoil ſhould contain leſs ſilica, and more of the other earths, than in a wet country.

Giobert found a fertile ſoil near Turin, where it rains annually 30 inches, to contain

From 77 to 79 ſilica,
9 — 14 alumina,
5 — 12 lime.

Near Paris, where it rains about 20 inches annually, Mr Tillet found a fertile ſoil to contain

Coarſe ſand 25
Fine ſand 21
— 46.0 ſilica,
16.5 alumina,
37.5 lime.
——
100.0 ‡

The varieties of mould are too numerous to admit an accurate deſcription: we ſhall content ourſelves, therefore, with mentioning the moſt remarkable.

127 Sand.

Species 1. Sand.

This conſiſts of ſmall grains of ſiliceous ſtones not cohering together, nor ſoftened by water. When the grains are of a large ſize, the ſoil is called *gravel*.

128 Clay.

Species 2. Clay.

This conſiſts of common clay mixed with decayed vegetable and animal ſubſtances.

129 Loam.

Species 3. Loam.

Any ſoil which does not cohere ſo ſtrongly as clay, but more ſtrongly than chalk, is called *loam*. There are many varieties of it. The following are the moſt common.

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* *Mem. Par.* 1779, 313.

† *Ann. de Chim.* xxx. 13.

‡ *Kirwan on Manures.*

Earths and Stones.

Variety 1. Clayey loam; called alſo *ſtrong*, *ſtiff*, *cold*, and *heavy*, loam.

It conſiſts of a mixture of clay and coarſe ſand.

Variety 2. Chalky loam.

A mixture of clay, chalk, and coarſe ſand; the chalk predominating.

Variety 3. Sandy loam.

A mixture of the ſame ingredients; the ſand amounting to .8 or .9 of the whole.

130 Till.

SPECIES 4. Till.

Till is a mixture of clay and oxyd of iron. It is of a red colour, very hard and heavy.

SECT. II. *Aggregates of amorphous ſtones.*

THE aggregates which belong to this ſection conſiſt of amorphous fragments of ſtones cemented together. They may be reduced to the following genera:

1. Sandſtone,
2. Puddingſtone,
3. Amygdaloid,
4. Breccia.

131 G I. Sandſtone.

GENUS I. SANDSTONE.

Small grains of ſand, conſiſting of quartz, flint, hornſtone, ſiliceous ſhiſtus, or felſpar, and ſometimes of mica, cemented together, are denominated ſandſtones. They feel rough and ſandy; and when not very hard, eaſily crumble into ſand. The cement or baſis by which the grains of ſand are united to each other is of four kinds; namely, lime, alumina, ſilica, iron. Sandſtones, therefore, may be divided into four ſpecies.

132 Calcareous.

SPECIES 1. Calcareous ſandſtones.

Calcareous ſandſtones are merely carbonat of lime or marl, with a quantity of ſand interpoſed between its particles. Though the quantity of ſand, in many caſes, far exceeds the lime, calcareous ſandſtones are ſometimes found cryſtallized: and, in ſome caſes, the cryſtals, as might be expected, have ſome of the forms which diſtinguiſh carbonat of lime. Thus the calcareous ſandſtone of Fountainbleau is cryſtallized in rhomboidal tables. It contains, according to the analyſis of Laſſone

62.5	ſiliceous ſand,
37.5	carbonat of lime.
100	

Calcareous ſandſtones have commonly an earthy texture. Their ſurface is rough. Their hardneſs from 6 to 7. Their ſpecific gravity about 2.5 or 2.6. Their colour grey; ſometimes yellowiſh or brown. They are ſometimes burned for lime.

133 Aluminous.

SPECIES 2. Aluminous ſandſtones.

The baſis of argillaceous ſandſtones is alumina, or rather clay. Their ſtructure is often ſlaty. Their texture is compact, and either fine or coarſe grained, according to the ſize of the ſand of which they are chiefly compoſed. Their hardneſs is from 6 to 8, or even 9. Their colour is uſually grey, yellow, or brown.

They are often formed into mill-ſtones, filtering-ſtones, and coarſe whet-ſtones.

134 Siliceous.

SPECIES 3. Siliceous ſandſtones.

Siliceous ſandſtones conſiſt of grains of ſand cemented together by ſilica, or ſome ſubſtance which conſiſts chiefly of ſilica or flint. They are much harder than any of the other ſpecies.

Aggregates

Sometimes ſtones occur, conſiſting of grains of lime cemented together with ſilica. Theſe ſtones are alſo denominated ſiliceous ſandſtones.

135 Ferruginous.

SPECIES 4. Ferruginous ſandſtones.

The iron which acts as a cement in ferruginous ſandſtones is not far from a metallic ſtate. When iron is completely oxydated, it loſes the property of acting as a cement. This is the reaſon that ferruginous ſandſtones, when expoſed to the air, almoſt always crumble into powder.

The colour of ferruginous ſandſtones is uſually dark red, yellow, or brown. The grains of ſand which compoſe them are often pretty large. Their hardneſs is commonly inconſiderable.

136 G. II. Pudding ſtone.

GENUS II. PUDDING STONE.

Pebbles of quartz, flint, or other ſimilar ſtones of a round or eliptical form, from the ſize of rape ſeed to that of an egg, cemented together by a ſiliceous cement, often mixed with iron, have been denominated *pudding ſtones*.

Pudding ſtones, of courſe, are not inferior in hardneſs to quartz, flint, chalcedony, &c. of which the pebbles may conſiſt. The colour of the cement is uſually yellow, brown, or red. Its fracture is conchoidal.

The finer ſorts of pudding ſtones are capable of a fine poliſh; the coarſe are uſed for mill-ſtones.

137 G. III. Amygdaloid.

GENUS III. AMYGDALOID.

Rounded or eliptical maſſes of chalcedony, zeolite, limeſtone, lithomarga, ſteatites, green earth, garnets, hornblend, or opal, cemented together by a baſis of indurated clay, trap, mullen, walken or kragg, conſtitute an *amygdaloid*.

Amygdaloids are opaque. They have no luſtre. Their fracture is uneven or conchoidal. Hardneſs 6 to 9. Their colours are as various as the ingredients of which they are compoſed.

138 G. IV. Breccia.

GENUS IV. BRECCIA.

Angular fragments of the ſame *ſpecies* of ſtone agglutinated together, conſtitute a *breccia*. Thus *calcareous* breccia conſiſts of fragments of marble cemented together by means of lime.

SECT. III. *Aggregates of Cryſtals.*

THE minerals belonging to this ſection conſiſt either of cryſtals of different kinds cemented together, or of cryſtals and amorphous ſtones cemented together.

They may be reduced under the following genera.

1. Granite.
2. Sienite.
3. Granatine.
4. Granitell.
5. Granilite.
6. Trap.
7. Porphyry.

139 G. I. Granite.

GENUS I. GRANITE.

An aggregate of felſpath, quartz, and mica, whatever be the ſize or the figure of the ingredients, is denominated *granite*. This aggregate may be divided into two ſpecies, namely, *common* granite, and *ſhiſtoſe* granite or gneiſs.

140 Common.

SPECIES 1. Common granite.

Its ſtructure is always granular. The felſpar is often amorphous, and conſtitutes moſt frequently the greateſt part of the aggregate.

Common granites differ much in their appearance, according to the ſize, proportion, colour, and figure of their component parts. They are commonly very hard: Their ſpecific gravity varies from 2.5388 to 2.9564.

141 Gneiſs. **SPECIES 2.** Shiſtoſe granite or gneiſs.

The ſtructure of gneiſs is always ſlaty, and this conſtitutes its ſpecific character. In gneiſs, the proportion of quartz and felſpar is nearly equal: the proportion of mica is ſmalleſt. It is evidently ſubject to the ſame varieties with common granite.

142 G. II. Sienite. Genus II. Sienite.

Mr Werner has given the name of *ſienite* to aggregates compoſed of felſpar, hornblende, and quartz; or of felſpar, hornblende, quartz, and mica. Theſe aggregates were formerly confounded with quartz.

Sienite is found both of a granular and ſlaty ſtructure: it might, therefore, like granite, be divided into two ſpecies. In ſienite the quartz is commonly in by far the ſmalleſt proportion.

143 G. III. Granatine. Genus III. Granatine.

Mr Kirwan has applied the name *granatine* to the following aggregates.

Quartz, Felſpar, Shorl.	Quartz, Mica, Garnet.	Quartz, Hornblende, Jade.	Felſpar, Mica, Shorl.
Quartz, Felſpar, Jade.	Quartz, Shorl, Hornblende,	Quartz, Hornblende, Garnet,	Felſpar, Mica, Hornblende.
Quartz, Felſpar, Garnet.	Quartz, Shorl, Jade.	Quartz, Jade, Garnet.	Felſpar, Quartz, Serpentine.
Quartz, Mica, Shorl.	Quartz, Shorl, Garnet.	Quartz, Hornblende, Hornſtone,	Felſpar, Quartz, Steatites.
Quartz, Mica, Jade.			

One of theſe aggregates, namely, *quartz, mica, garnet*, was called by Cronſtedt *norka* or *murkſten*.

144 G. IV. Granitell. Genus IV. Granitell.

Mr Kirwan gives the name of *granitell* to all aggregates compoſed of any two of the following ingredients: quartz, felſpath, mica, ſhorl, hornblende, jade, garnet, ſteatites. The moſt remarkable of theſe are:

Quartz, Felſpar.	Quartz, Hornblende.	Quartz, Steatites.	Felſpar, Hornblende.
Quartz, Mica.	Quartz, Jade.	Felſpar, Mica.	Felſpar, Jade.
Quartz, Shorl.	Quartz, Garnet.	Felſpar, Shorl.	Felſpar, Garnet.
Mica, Shorl.	Mica, Jade.	Hornblende, Jade.	Jade, Garnet.
Mica, Hornblende.	Mica, Garnet.	Hornblende, Garnet.	Steatites, Shorl.

Some of theſe aggregates have received particular names. The aggregate of *quartz* and *mica*, when its ſtructure is ſlaty, is called by Werner *ſhiſtoſe mica:* by the Swedes, it is denominated *ſtellſten*, whatever be its ſtructure.

The aggregate of hornblende and mica is called *grunſtein*, from the dark green colour which it uſually has.

145 G. V. Granilite. Genus V. Granilite.

Under the name of *granilite*, Mr Kirwan comprehends all aggregates containing more than three ingredients. Of theſe the following are the moſt remarkable.

Quartz, Felſpar, Mica, Shorl.	Quartz, Mica, Shorl, Garnet.	Quartz, Sulph. of barytes, Mica, Shorl.
Quartz, Felſpar, Mica, Steatites.	Quartz, Felſpar, Mica, Garnet.	Quartz, Sulph. of barytes, Mica, Hornblende.

146 G. VI. Trap. Genus VI. Trap (p).

Under this genus we claſs not only what has commonly been called *trap*, but alſo wacken, and mullen, and kragſtone of Kirwan.

147 Common. **SPECIES 1.** Common trap.

This ſtone is very common in Scotland, and is known by the name of *whinſtone*. Whole hills are formed of it; and it occurs very frequently in large rounded detached fragments. Sometimes it aſſumes the form of immenſe columns, and is then called *baſalt*. The Giants Cauſeway in Ireland, the iſland of Staffa, and the ſouth ſide of Arthur's Seat in Scotland, are well known inſtances of this figure.

Its texture is earthy or compact. Its fracture uneven. Its luſtre commonly 0. Opaque. Hardneſs 8 to 9. Not brittle. Sp. gr. from 2.78 to 3.021 *. Colour black, with a ſhade of grey, blue, or purple; ſometimes blackiſh or reddiſh brown; in ſome caſes greeniſh grey. By expoſure to the atmoſphere, it often becomes inveſted with a browniſh rind. Before the blow-pipe, it melts *per ſe* into a more or leſs black glaſs.

Trap conſiſts of ſmall cryſtals of hornblende, felſpar, olivine, &c. uſually ſet in a ground compoſed apparently of clay and oxyd of iron. A ſpecimen, in the form of baſaltes, from Staffa, analyſed by Dr Kennedy of Edinburgh, contained

48	ſilica,
16	alumina,
16	oxyd of iron,
9	lime,
5	moiſture,
4	ſoda,
1	muriatic acid.
99 †	

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* *Kirwan.*

† *Edin. Tranſ.* v. 89.

(p) *Kirw.* I. 231 and 431.—*Faujas de St Fond. Eſſai ſur l'Hiſt. Nat. des Roches de Trap.—Phil. Tranſ.* paſſim. See alſo a very ingenious ſet of experiments on the fuſion of trap, by Sir James Hall in *Tranſ. Edin.* V. 43.

A ſpecimen from Saliſbury rock, near Edinburgh, contained, according to the analyſis of the ſame gentleman,

46.0	ſilica,
19.0	alumina,
17.0	oxyd of iron,
8.0	lime,
4.0	moiſture,
3.5	ſoda,
1.0	muriatic acid.
98.5 ‡	

Dr Kennedy conducted theſe analyſes with great ingenuity and judgment; and the diſcovery in which they terminated, that trap contains ſoda, is certainly of importance, and may lead to valuable conſequences both in a geological and mineralogical view.

148 Wacken.

SPECIES 2. Wacken *.

This ſtone often forms conſiderable parts of hills, and, like trap, is amorphous. Its texture is earthy. Its fracture uſually even. Luſtre 0. Opaque. Hardneſs 6 to 9. Sp. gr. from 2.535 to 2.893 †. Colour grey, with a ſhade of green, black, red, brown. When expoſed to the atmoſphere, it withers and becomes more grey.

It melts into a grey porous ſlag.

149 Mullen.

SPECIES 3. Mullen ‡.

This ſtone is alſo found in conſiderable maſſes, and ſometimes has a tendency to a columnar form like baſalt. Texture earthy. Fracture uneven, and fine ſplintery. Luſtre 0, except from ſome ſhining particles of baſaltine. Opaque. Hardneſs from 7 to 9. Sp. gr. from 2.6 to 2.738. Colour aſh or bluiſh grey; ſometimes mixed with ochre yellow, in conſequence of the decompoſition of the ſtone. At 130° Wedgewood it melts into a black compact glaſs.

When mullen is expoſed to the air, its ſurface becomes covered with a greyiſh white rind, ſometimes ſlightly ochry.

150 Kragſtone.

SPECIES 4. Kragſtone *.

This ſtone, which, like the others, forms conſiderable parts of rocks, was formed into a diſtinct ſpecies by Mr Kirwan. Its texture is earthy. It is exceedingly porous, and the pores are often filled with the cryſtals of other minerals. Fracture uneven. Luſtre 0. Opaque. Hardneſs 5 to 7. Sp. gr. 2.314. Feels rough and harſh. Colour reddiſh grey. Streak yellowiſh grey. At 138° Wedgewood it melts into a reddiſh brown porcelain maſs.

151 G. VII. Porphyry.

GENUS VII. PORPHYRY.

Any ſtone which contains ſcattered cryſtals or grains of felſpar, viſible to the naked eye, is denominated a *porphyry*. Beſides felſpar, porphyries generally contain ſmall cryſtals of quartz, hornblende, and mica. Theſe cryſtals are uſually of a different colour from the ſtone in which they are found, and they are ſtuck in it as in a cement. It is evident from this definition, that the number of porphyries muſt be great. Each ſpecies receives its name from the ſtone which forms its baſis. To deſcribe them would be unneceſſary. We ſhall only give a catalogue of the principal ſpecies.

1. Hornſtone porphyry.
2. Pitchſtone porphyry.
3. Hornſlate porphyry.
4. Felſpar or petunſe porphyry.
5. Clay porphyry.
6. Hornblende porphyry.
7. Trap porphyry.
8. Wacken porphyry.
9. Mullen porphyry.
10. Krag porphyry.
11. Argillitic porphyry.
12. Potſtone porphyry.
13. Serpentine porphyry.
14. Sandſtone porphyry.

The aggregates belonging to this ſection compoſe moſt of the mountains of the globe. In giving an account of them, we have adhered implicitly to the arrangement moſt generally received by mineralogiſts. It muſt be acknowledged, that this arrangement is by no means complete, and that ſome of the genera are too vague to be of much uſe. The number of aggregates already diſcovered is too great for giving to each a particular name. Perhaps it would be better henceforth to adopt the method propoſed by Mr Hauy, namely, to conſtitute the genera from that ingredient which enters moſt abundantly into the aggregate, and which forms as it were its baſis, and to diſtinguiſh the ſpecies according to the nature and proportion of the other ingredients. According to this plan, the aggregates hitherto diſcovered have been divided by Hauy into the following genera:

1. Felſpathic rock.
2. Quartzous rock.
3. Micaceous rock.
4. Chloritous rock.
5. Serpentine rock.
6. Trappean rock.
7. Hornblendean rock.
8. Petro-ſiliceous rock.
9. Garnetic rock.
10. Calcareous rock.
11. Argillaceous rock.
12. Corneous rock.

SECT. IV. *Volcanic Aggregates.*

AGGREGATES formed by volcanoes may be reduced to the following genera.

1. Lava.
2. Tufa.
3. Pumice.
4. Aſhes.

152 G. I. Lava.

GENUS I. LAVA.

All ſubſtances which have iſſued out of a volcano in a ſtate of fuſion are called *lavas*. They have been divided into three ſpecies.

153 Vitreous.

SPECIES 1. Vitreous lava.

Found in ſmall pieces.

Texture gloſſy. Fracture conchoidal. Luſtre 3. Tranſparency from 3 to 1. Hardneſs 9 to 10. Sp. gr. from 2 to 3. Colour blackiſh, greeniſh, or whitiſh. Commonly ſomewhat porous.

154 Cellular.

SPECIES 2. Cellular lava.

This ſpecies is full of cells. Surface rough and full of cavities. Texture earthy. Luſtre 0. Opaque. Hardneſs 7 to 9. Sp. gr. varies, but does not exceed 2.8. Colour brown or greyiſh black. Commonly ſomewhat magnetic.

155 Compact.

SPECIES 3. Compact lava.

This ſpecies is the moſt common of all; it runs into

the

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‡ *Edin. Tranſ.* v. 90.

* *Kirw.* i. 223.

† *Kirwan.*

‡ *Kirw.* i. 225.

* *Kirw.* i. 226.

Combuſtibles.

the ſecond by inſenſible degrees; and indeed is ſeldom found of any conſiderable ſize without ſome pieces. It bears in general a very ſtrong reſemblance to trap.

A ſpecimen of the lava of Catania in Sicily, analyſed by Dr Kennedy, contained

51.0	ſilica,
19.0	alumina,
14.5	oxyd of iron,
9.5	lime,
4.0	ſoda,
1.0	muriatic acid.
99.0 †	

† Tranſ. Edin. v. 93.

A ſpecimen of the lava of Sta. Venere in Sicily he found to contain

50.75	ſilica,
17.50	alumina,
14.25	oxyd of iron,
10.00	lime,
4.00	ſoda,
1.00	muriatic acid.
97.5 ‡	

‡ Ibid. 94.

Thus we ſee, that the reſemblance between trap and lava holds not only in their external appearance, but alſo in their component parts.

156 G. II. Puzzolana.

Genus II. PUZZOLANA.

Found in ſmall pieces. Surface rough. Texture earthy and porous. Fracture uneven. Luſtre 0. Opaque. Hardneſs 3. Very brittle. Sp. gr. from 2.57 to 2.8. Colour brown or dark grey. Magnetic. Eaſily melts into a black ſlag.

When mixed with lime into a mortar, it poſſeſſes the property of hardening even under water. This property it owes moſt probably, as Mr Kirwan ſuppoſes, to the iron which it contains. The iron decompoſes the water of the mortar, and by this means it becomes too hard to be acted upon by water in a very ſhort time.

157 G. III. Pumice.

Genus III. PUMICE.

This is a very light ſubſtance ejected from volcanoes. It is porous. Hardneſs 3. Brittle. Sp. gr. below 1. Colour grey or brown.

In ſome varieties the luſtre and tranſparency are 0: in others, the luſtre is glaſſy, 2. Tranſparency from 1 to 2.

158 G. IV. Volcanic aſhes.

Genus IV. VOLCANIC ASHES.

Theſe are analogous to the aſhes of common pit coal. Looſe and ſmooth, very light, and fine. Slowly diffuſible in water, and when wet ſomewhat ductile.

Class II. SALTS.

UNDER this claſs we comprehend all the combinations of alkalies with acids which exiſt in the mineral kingdom. As they have been already deſcribed in the article Chemistry, *Suppl.* we ſhall here only give a liſt of their names.

159 Genera.

Genus I. POTASS.

Sp. 1. Sulphat of potaſs.
2. Nitrat of potaſs.

Genus II. SODA.

Sp. 1. Carbonat of ſoda.
2. Sulphat of ſoda.
3. Muriat of ſoda.
4. Borax.

Genus III. AMMONIA.

Sp. 1. Sulphat of ammonia.
2. Muriat of ammonia.

Class III. COMBUSTIBLES.

160 Genera.

THE combuſtible ſubſtances belonging to the mineral kingdom, excluding the metals, may be comprehended under the following genera.

1. Sulphur.
2. Carbon.
3. Bitumen.
4. Coal.
5. Amber.

161 G. I. Sulphur.

Genus I. SULPHUR.

SPECIES 1. Native ſulphur.

This ſubſtance is found abundantly in many parts of the world, eſpecially near volcanoes, as Hecla, Ætna, Veſuvius, the Lipari iſlands, &c. It is either in the ſtate of powder, or maſſive, or cryſtallized. The primitive form of its cryſtals is an octohedron, compoſed of two four-ſided pyramids, joined baſe to baſe †. The ſides of theſe pyramids are ſcalene triangles, and ſo inclined that the plane where the baſes of the pyramids join is a rhomb, whoſe long diagonal is to its ſhort as 5 to 4 *. Sometimes the apices of the pyramids, to uſe the language of De Liſle, are truncated; ſometimes they are ſeparated from each other by a priſm; ſometimes they are truncated near their baſes, and a low four-ſided pyramid riſes from the truncature: this pyramid is alſo ſometimes truncated near its apex ‡. Finally, one of the edges of the pyramids is ſometimes truncated. For figures of theſe varieties, and for the laws of their formation, we refer to *Mr Lefroy* †.

† Fig. 34.

* Romé de Liſle, i. 292. Haüy and Lefroy, Jour. de Min. Nº xxix. 337.

‡ Fig. 35.

† Jour. de Min. Nº xxix. 337.

Colour yellow, with a ſhade of green; ſometimes reddiſh (a). Luſtre greaſy, 2. Tranſparency varies from 0 to 4. Cauſes double refraction ‡. Texture compact. Hardneſs 4 to 5. Brittle.—For its other properties, we refer to Chemistry in this *Suppl.*

‡ Haüy.

Sometimes ſulphur is mixed with different proportions of earths. Theſe combinations are hardly ſuſceptible of accurate deſcription.

Sulphur combines alſo with metals. Theſe combinations ſhall be deſcribed in the fourth claſs.

162 G. II. Carbon.

Genus II. CARBON.

This genus comprehends all minerals compoſed of pure carbon, or of carbon combined with a little earth.

163 Diamond.

SPECIES 1. Diamond.

This mineral, which was well known to the ancients, is

(a) It then contains arſenic.

Combuſtibles.

is found in different parts of Aſia, particularly in the kingdoms of Golconda and Viſapoor; it is found alſo in Brazil.

It is always cryſtallized; but ſometimes ſo imperfectly, that at the firſt ſight it might paſs for amorphous. Its primitive form is a regular octogon†; but it more commonly aſſumes a ſpheroidal form, and then has uſually 36 curvilinear triangular faces, ſix of which are raiſed upon each of the faces of the primitive octogon‡. Its integrant molecule, according to Hauy, is a regular tetrahedron.—For a more particular account of the cryſtals of this mineral, we refer the reader to *Mr Romé de Liſle** and *Mr Hauy*†.

† Fig. 36.
‡ Fig. 37.
* *Cryſt.* ii. 191.
† *Jour. de Min.* N° xxix. 343.

Texture foliated. Luſtre 4. Tranſparency from 2 to 4. Cauſes ſingle refraction. Hardneſs 20. Sp. gr. 3.5185 to 3.5310‡. Colour various; ſometimes limpid, ſometimes red, orange, yellow, green, blue, and even blackiſh.

‡ *Hauy, ibid.*

When rubbed it becomes poſitively electric, even before it has been cut by the lapidary, which is not the caſe with any other gem‖.

It is compoſed of pure carbon§.

‖ *Id. ibid.*
§ *Morveau, Ann. de Chim.* xxxi. 72.

164 Mineral charcoal.

SPECIES 2. Mineral charcoal.

Kilkenny coal—Wales culm.

This mineral has been found in Hungary, Italy, France, Ireland, and Wales. It occurs in ſtratified maſſes, or in lumps neſted in clay.

Colour black. Luſtre 4, metallic. Opaque. Texture foliated. Hardneſs 5 to 7. Sp. gr. 1.4 to 1.526. Often ſtains the fingers. Inſoluble in acids. Deflagrates with nitre. Does not burn till wholly ignited, and then conſumes ſlowly without emitting flame or ſmoke.

It conſiſts almoſt entirely of *charcoal*, which, as Morveau has proved, is an oxyd of carbon*.

* *Ibid.*

165 Anthracite.

SPECIES 3. Anthracite (R).

Anthracolite.

This ſubſtance, as Dolomieu informs us, is found excluſively in the primitive mountains. It is always amorphous. Colour black or browniſh black. Luſtre 3 to 4. Structure ſlaty. Fragments rhomboidal. Hardneſs 6 to 7. Sp. gr. greater than that of coal. Often ſtains the fingers.

Burns preciſely like the laſt ſpecies, and leaves .40 of white aſhes. According to Dolomieu, it is compoſed of about

64.0	charcoal,
32.5	ſilica,
3.5	iron,
100.0†	

† *Jour. de Min* N° xxix. 338.

It is probable that the charcoal in the two laſt ſubſtances is in the ſame ſtate in which it exiſts in plumbago, combined with oxygen, but not containing ſo much as charcoal does‡.

‡ *Morveau, ibid.*

166 G. III. Bitumen.

GENUS III. BITUMEN.

By bitumen we underſtand, with mineralogiſts in general, an oil, which is found in different parts of the earth, in various ſtates of conſiſtence. Theſe different ſtates form diſtinct ſpecies; in our arrangement of which we ſhall be guided by the obſervations which Mr Hatchett has made in his valuable paper on bituminous ſubſtances*.

* *Nicholſon's Journal*, ii. 201, 248.

167 Naphtha.

SPECIES 1. Naphtha.

This ſubſtance is found ſometimes on the ſurface of the water of ſprings, and ſometimes iſſuing from certain ſtrata. It is found in great abundance in Perſia.

It is as fluid and tranſparent as water. Colour white or yellowiſh white. Smell ſtrong, but not diſagreeable. Sp. gr. when white, .708* or .729†; when yellowiſh, .8475‡. Feels greaſy. Catches fire on the approach of flame, burns with a white flame, and leaves ſcarce any reſiduum.

* *Muſchenbroek*
† *Bouldoc.*
‡ *Briſſon.*

Inſoluble in alcohol. Does not freeze at 0° Fahrenheit. When pure naphtha is expoſed to the air, it becomes yellow and then brown; its conſiſtence is increaſed, and it paſſes into *petroleum**.

* *Hatchett.*

168 Petroleum.

SPECIES 2. Petroleum.

This ſubſtance is alſo found in Perſia, and likewiſe in many countries in Europe, particularly Italy, France, Switzerland, Germany, Sweden, England, and Scotland.

Not ſo fluid nor tranſparent as water. Colour yellow, either pale or with a ſhade of red or green; reddiſh brown and reddiſh black. Smell that of naphtha, but leſs pleaſant. Sp. gr. .8783*. When burned it yields a ſoot, and leaves a ſmall quantity of coally reſiduum.

* *Briſſon.*

By expoſure to the air it becomes like tar, and is then called *mineral tar*†.

† *Hatchett, ibid.*

169 Mineral tar.

SPECIES 3. Mineral tar.

This ſubſtance is found in many parts of Aſia, America, and Europe. It is viſcid, and of a black, browniſh black, or reddiſh colour. Smell ſometimes ſtrong, but often faint. Sp. gr. 1.1. When burned, emits a diſagreeable bituminous ſmell. By expoſure to the air it paſſes into *mineral pitch* and *maltha**.

* *Hatchett, ibid.*

170 Mineral pitch and maltha.

SPECIES 4. Mineral pitch and maltha.

This ſubſtance has a ſtrong reſemblance to common pitch. When the weather is warm it is ſoft, and has ſome tenacity; it is then called *adheſive mineral pitch*: when the weather is cold, it is brittle; its hardneſs is 5; and its fracture has a glaſſy luſtre. In this ſtate it is called *maltha*. Colour black, dark brown, or reddiſh. Luſtre 2. Opaque. Sp. gr. from 1.45 to 2.07. Does not ſtain the fingers. On a white hot iron it flames with a ſtrong ſmell, and leaves a quantity of grey aſhes. It is to the preſence of the earths which compoſe theſe aſhes that the great ſpecific gravity of this bitumen is to be aſcribed. By farther induration, it paſſes into *aſphalt*.

171 Aſphalt.

SPECIES 5. Aſphalt.

This ſubſtance is found abundantly in many parts of Europe, Aſia, and America, eſpecially in the iſland of Trinidad.

Colour black or browniſh black. Luſtre greaſy 2. Opaque. Fracture conchoidal, of a glaſſy luſtre. Hardneſs from 7 to 8. Very brittle. Sp. gr 1.07 to 1.165*. Feel ſmooth, but not greaſy. Does not ſtain the fingers. Has little or no ſmell, unleſs when rubbed or heated. When heated melts, ſwells, and inflames; and when pure, burns without leaving any aſhes.

* *Kirwan.*

172 Elaſtic bitumen.

SPECIES 6. Elaſtic bitumen.

Mineral cahutchouc.

This ſubſtance was found about the year 1785 in the lead

(R) This name was given by Hauy from ανθραξ, *a coal.*

lead mine of Odin, near Caſtletown, Derbyſhire. It was firſt mentioned by Mr De Born.

Colour yellowiſh or reddiſh brown, ſometimes blackiſh brown. In its appearance it has a ſtrong reſemblance to caoutchouc or Indian rubber; hence its name. Conſiſtency various: ſometimes ſo ſoft as to adhere to the fingers; ſometimes nearly as hard as aſphalt. When ſoft it is elaſtic; when hard brittle. Sp. gr. 0.9053 to 1.0233‡.

‡ Hatchett, ibid.

Inſoluble in alcohol, ether, and oil of turpentine, but ſoluble in oil of olives. Not affected by nitric acid. When diſtilled, it yields a bituminous oil inſoluble in alcohol; the reſiduum is carbonaceous*.

* Lametherie, Jour. de Phyſ. xxxi. 312.

There is a variety of this ſubſtance found in a rivulet near the mine of Odin, which, when freſh cut, exactly reſembles fine cork in colour and texture; but in a few days after being expoſed to the air, becomes of a pale reddiſh brown. This ſubſtance contains within it a nucleus of elaſtic bitumen. It ſeems to be the elaſtic bitumen altered in its texture by the water †.

† Hatchett, ibid.

173 G. IV. Coal.

Genus IV. coal.

The ſubſtances belonging to this genus are compoſed of carbon or rather charcoal, and bitumen.

174 Jet.

species 1. Jet (s).

This ſubſtance is found in France, Spain, Germany, Britain, and other countries. It is found in detached kidneyform maſſes, of various ſizes, from an inch to ſeven or eight feet in length.

Colour full black. Luſtre 3 to 4; internal glaſſy. Opaque. Hardneſs 7 to 8. Not near ſo brittle as aſphalt. Texture ſtriated. Fracture conchoidal. Sp. gr. 1.259*. It has no odour except when heated, and then it reſembles the odour of aſphaltum. Melts in a ſtrong heat, burns with a greeniſh flame, and leaves an earthy reſiduum†.

* Briſſon.

† Hatchett.

Becomes ſomewhat electric by friction ‡. When diſtilled yields a peculiar acid §.

‡ Kirwan.

§ Vauquelin.

This mineral is formed into buttons, beads, and other trinkets. The manufacture has been almoſt confined to France ‖.

‖ Jour. de Min. N° iv. 41.

175 Cannel coal.

species 2. Cannel coal.

This mineral is found in Lancaſhire, and in different parts of Scotland, where it is known by the name of *parrot coal.*

Colour black. Luſtre common, 2. Opaque. Structure ſometimes ſlaty. Texture compact. Fracture conchoidal. Hardneſs 5 to 8. Brittle. Sp. gr. 1.232 to 1.426. Does not ſtain the fingers.

Kindles eaſily, and burns with a bright white flame like a candle (t), which laſts but a ſhort time. It does not cake. It leaves a ſtony or ſooty reſiduum.

A ſpecimen of Lancaſhire cannel coal, analyſed by Mr Kirwan, contained

75.20 charcoal,
21.68 maltha,
3.10 alumina and ſilica.
99.98†

† Mineral. 523.

A ſpecimen of the ſlaty kind from Airſhire, called *ſplent coal*, was compoſed of

47.62 charcoal,
32.52 maltha,
20.00 earths.
100.14‡

‡ Ibid. 524.

Cannel coal is ſuſceptible of poliſh, and, like jet, is often wrought into trinkets.

176 Common coal.

species 3. Common coal.

This very uſeful combuſtible is never found in the primitive mountains, but only in the ſecondary mountains, or in plains formed of the ſame materials with them. It is always in ſtrata, and generally alternates with clay, ſandſtone, or limeſtone.

Colour black, more or leſs perfect. Luſtre uſually greaſy or metallic, 2 to 4. Opaque. Structure generally ſlaty. Texture often foliated. Fracture various. Hardneſs 4 to 6. Sp. gr. 1.25 to 1.37. Uſually ſtains the fingers. Takes fire more ſlowly, and burns longer, than the laſt ſpecies. Cakes more or leſs during combuſtion.

Of this ſpecies there are many varieties, diſtinguiſhed in Britain by the names of caking coal, rock coal, &c. Theſe are too well known to require any deſcription.

Mr Kirwan analyſed a variety of different kinds of coal: The reſult of his experiments may be ſeen by the following table.

Whitehaven coal.	Wigan.	Swanſey.	Leeirim.	
57.0	61.73	73.53	71.43	charcoal.
41.3	36.7	23.14	23.37	maltha & aſph.
1.7	1.57	3.33	5.20	earths ‡.
100.0	100.00	100.00	100.00	

‡ Mineral. ii. 525.

177 Spurious coal.

species 4. Spurious coal.

This mineral is generally found amidſt ſtrata of genuine coal. It is alſo called *parrot-coal* in Scotland.

Colour greyiſh black. Luſtre 0 to 1. Structure uſually ſlaty. Texture earthy. Hardneſs 7 to 8. Sp. gr. 1.5 to 1.6 Generally explodes, and burſts when heated.

Compoſed of charcoal, maltha, and aſphalt, and above .20 of ſtony matter.

178 G. V. Amber.

Genus V. amber.

species 1. Common amber.

This ſubſtance, called *electrum* by the ancients, is found in different countries; but moſt abundantly in Pruſſia, either on the ſea-ſhore, or under ground at the depth of about 100 feet, repoſing on *wood coal**. It is in lumps of different ſizes.

* Kirw. Min. ii. 66.

Colour yellow. Luſtre 3 to 2. Tranſparency 2 to 4. Fracture conchoidal. Hardneſs 5 to 6. Sp. gr. 1.078 to 1.085. Becomes electric by friction.

If a piece of amber be fixed upon the point of a knife, and then kindled, it burns to the end without melting †.

† Hauy.

By diſtillation it yields ſuccinic acid.

Class

(s) It was called *gagathes* by the ancients, from the river Gages in Licia, near which it was found; *jayet* in French, *ozabache* in Spaniſh, *gagath* in German.

(t) Hence it has been called *cannel coal*. *Candle*, in the Lancaſhire and Scotch dialect, is pronounced *cannel*.

CLASS IV. METALLIC ORES.

THIS claſs comprehends all the mineral bodies, compoſed either entirely of metals, or of which metals conſtitute the moſt conſiderable and important part. It is from the minerals belonging to this claſs that all metals are extracted; for this reaſon they have obtained the name of *ores*.

179 Orders. The metals hitherto diſcovered amount to 21; we ſhall therefore divide this claſs into 21 orders, allotting a diſtinct order for the ores of every particular metal.

Metals exiſt in ores in one or other of the four following ſtates. 1. In a metallic ſtate, and either ſolitary or combined with each other. 2. Combined with ſulphur. 3. In the ſtate of oxyds. 4. Combined with acids. Each order therefore may be divided into the four following genera.

180 Genera.

1. Alloys.
2. Sulphurets.
3. Oxyds.
4 Salts.

It muſt be obſerved, however, that every metal has not hitherto been found in all theſe four ſtates, and that ſome of them are hardly ſuſceptible of them all. Some of the orders therefore want one or more genera, as may be ſeen from the following table.

ORDER I. *Gold ores.*
  1. Alloys.
ORDER II. *Silver ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER III. *Platinum ores.*
  1. Alloys.
ORDER IV. *Ores of mercury.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER V. *Copper ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER VI. *Iron ores.*
  1. Alloys.
  2. Sulphurets.
  3. Carburets.
  4. Silicated iron.
  5. Oxyds.
  6. Salts.
ORDER VII. *Tin ores.*
  1. Sulphurets.
  2. Oxyds.
ORDER VIII. *Lead ores.*
  1. Sulphurets.
  2. Oxyds.
  3. Salts.
ORDER IX. *Zinc ores.*
  1. Sulphurets.
  2. Oxyds.
  3. Salts.
ORDER X. *Antimonial ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER XI. *Biſmuth ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
ORDER XII. *Arſenic ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
ORDER XIII. *Cobalt ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER XIV. *Nickel ores.*
  1. Sulphurets.
  2. Oxyds.
  3. Salts.
ORDER XV. *Mangneſe ores.*
  1. Oxyds.
  2. Salts.
ORDER XVI. *Tungsten ores.*
  1. Oxyds.
  2. Salts.
ORDER XVII. *Ores of molybdenum.*
  1. Sulphurets.
ORDER XVIII. *Ores of uranium.*
  1. Oxyds.
  2. Salts.
ORDER XIX. *Ores of titanium.*
  1. Oxyds.
ORDER XX. *Ores of tellurium.*
  1. Alloys.
ORDER XXI. *Ores of chromum.*
  1. Oxyds.

ORDER I. GOLD ORES.

181 Where found. No metal perhaps, if we except iron, is more widely ſcattered through the mineral kingdom than gold[*]. Hitherto it has been found only in a metallic ſtate; moſt commonly in grains, ramifications, leaves, or rhomboidal, octohedral, or pyramidal cryſtals. It is generally mixed with quartz, though there are inſtances of its having occurred in calcareous rocks. It is not uncommon alſo to find it diſſeminated through the ores of other metals; eſpecially iron, mercury, copper, and zinc. The greateſt quantity of gold is found in the warmer regions of the earth. It abounds in the ſands of many African rivers, and is very common in South America and India. Europe, however, is not deſtitute of this metal. Spain was famous in ancient times for its gold mines, and ſeveral of the rivers in France contain it in their ſands[†]. But the principal gold mines in Europe are thoſe of Hungary, and next to them thoſe of Salzburg. Gold alſo has been diſcovered in Sweden and Norway, and more lately in the county of Wicklow in Ireland[‡].

GENUS I. Alloys of gold.

SPECIES 1. Native gold.

182 G. I. Native gold. Native gold is never completely pure; it is alloyed with ſome ſilver or copper, and ſometimes with iron. In the native gold found in Ireland, indeed, the quantity of alloy appears to have been exceedingly ſmall.

Its colour is yellow. Luſtre metallic. Fracture hackly. Hardneſs 5. Sp. gr. from 12 to 19.

ORDER II. SILVER ORES.

183 Where found. SILVER is found moſt commonly in quartz, limeſtone, hornſtone; or combined with the ores of other metals, moſt commonly with copper, antimony, zinc, cobalt, and lead. This laſt metal indeed is ſeldom totally deſtitute of ſilver.

GENUS I. Alloys of ſilver.

SPECIES 1. Native ſilver[*].

184 G. I. Native ſilver. Native ſilver, ſo called becauſe the ſilver is nearly in a ſtate of purity, forms the principal part of ſome of the richeſt ſilver mines in the world. It is ſometimes in ſmall lumps; ſometimes cryſtallized in cubes, hexahedrons, octohedrons, or dodecahedrons; ſometimes in leaves, or threads, often ſo connected with each other as to reſemble branches of trees, and therefore called *dendrites*. The ſilver in the famous mines of Potoſi has this laſt form. When newly extracted, it is not unlike ſmall branches of fir[†].

The colour of native ſilver is white; often tarniſhed. Luſtre metallic. Fracture hackly. Hardneſs 6. Malleable. Sp. gr. from 10 to 10.338.

The ſilver in this ſpecies is almoſt conſtantly alloyed with from .03 to .05 of ſome other metal, frequently gold or arſenic.

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[*] *Bergman.*

[†] *Reaumur, Mem. Par.* 1718, p. 68.

[‡] *Lloyd, Phil. Tranſ.* 1796, p. 31. *Mills, ibid.* p. 38.—*Nicholſon's Journ.* ii. 224.

[*] *Kirw.* ii. 108.—*Colling. Act. Liter. Suecia,* 1738, p. 420.

[†] *Bergman's Phyſ. Geogr. Jour. de Min.* No xvi. p. 26.

SPECIES 2. Alloy of ſilver and gold.

Auriferous native ſilver.

185 Alloy of ſilver and gold.

This alloy is not uncommon in ſilver mines. Its colour is yellowiſh white. Its luſtre metallic. Hardneſs 5. Malleable. Sp. gr. above 10.6. Dr Fordyce found a ſpecimen from Norway compoſed of

72 ſilver,
28 gold.
100*

SPECIES 3. Alloy of ſilver and antimony †.

Antimoniated ſilver ore.

186 Alloy of ſilver and antimony.

This alloy, which is found in the ſilver mines of Spain and Germany, is ſometimes in grains or lumps, and ſometimes cryſtallized in ſix-ſided priſms, whoſe ſides are longitudinally channelled ‡.

Its colour is white. Its luſtre metallic. Hardneſs 10. Brittle. Sp. gr. from 9.4406§ to 10‖. Texture foliated. Fracture conchoidal. Before the blow-pipe the antimony evaporates in a grey ſmoke, and leaves a browniſh ſlag, which tinges borax green. If borax be uſed at firſt, a ſilver bead may be obtained.

This alloy was long ſuppoſed to contain arſenic. Bergman examined it, and found only ſilver and antimony ¶. His analyſis has been confirmed by the experiments of Vauquelin and Selb *. According to Selb, it is compoſed of 89 ſilver,
11 antimony.
100

A ſpecimen, analyſed by Klaproth, contained
84 ſilver,
16 antimony.
100

Another ſpecimen contained
76 ſilver,
24 antimony.
100 †

GENUS II. SULPHURETS OF SILVER.

SPECIES 1. Common ſulphuret of ſilver ‡.

Vitreous ſilver ore.

187 G. II. Sulphurets. Common ſulphuret of ſilver.

This ore occurs in the ſilver mines of Germany and Hungary. It is ſometimes in maſſes, ſometimes in threads, and ſometimes cryſtallized. Its cryſtals are either cubes or regular octohedrons, whoſe angles and edges are often variouſly truncated. For a deſcription of the varieties produced by theſe truncatures, we refer the reader to *Romé de Liſle* ¶.

Its colour is dark bluiſh grey, inclining to black; often tarniſhed. Internal luſtre metallic. Texture foliated. Fracture uneven. Hardneſs 4 to 5. May be cut with a knife like lead. Flexible and malleable. Sp. gr. 6.909* to 7.215†. In a gentle heat the ſulphur evaporates. Melts when heated to redneſs.

A ſpecimen of this ore, analyſed by Klaproth, contained
85 ſilver,
15 ſulphur.
100‡

SPECIES 2. Antimoniated ſilver ore *.

Sulphuret of ſilver with antimony and iron.

188 Antimoniated ſilver ore.

This ore, which occurs in Saxony and Hungary, ſeems to be ſulphuret of ſilver contaminated with antimony and iron, and ought therefore, in all probability, to be conſidered merely as a variety of the laſt ſpecies. It is ſometimes in maſſes, but more frequently cryſtallized in ſix-ſided priſms, tables, or rhomboids; generally indiſtinct and accumulated together.

Its colour is iron grey; often tarniſhed. Its luſtre metallic. Fracture uneven. Hardneſs 4 to 5. Brittle. Sp. gr. 7.208†. Before the blow-pipe the ſulphur and antimony exhale, leaving a bead, which may be freed from iron by fuſion with nitre and borax.

A ſpecimen of this ore, analyſed by Klaproth, contained
66.5 ſilver,
12.0 ſulphur,
10,0 antimony,
5.0 iron,
1.0 ſilica,
0.5 arſenic and copper.
95.0‡

SPECIES 3. Sulphuret of ſilver and copper *.

Cupriferous ſulphurated ſilver ore.

189 Sulphuret of ſilver and copper.

This ore, which is found in the Korbolokinſk mountains in Siberia, was firſt deſcribed by Mr Renovantz. It is in amorphous maſſes, varying in ſize from that of the thumb to that of the fiſt.

Its colour is bluiſh grey like lead. Luſtre metallic. Hardneſs 5 to 6. Brittle. Its powder, when rubbed on the ſkin, gives it a black colour and a leaden gloſs. Before the blow-pipe the ſulphuret of ſilver melts readily; that of copper with difficulty. This ore is compoſed of about
42 ſilver,
21 copper,
35 ſulphur.
98

GENUS III. OXYDS OF SILVER.

SPECIES 1. Calciform ſilver ore †.

190 G. III. Oxyds. Calciform ſilver ore.

This ore was firſt deſcribed by Mr Widenman. It is ſometimes in maſſes, ſometimes diſſeminated through other minerals.

Its colour is greyiſh black. Its ſtreak bright. Its luſtre metallic. Its fracture uneven. Hardneſs 4 to 5. Brittle. Sp. gr. conſiderable. Effervesces with acids. Melts eaſily before the blow-pipe. Froths with borax.

According to Selb, it contains 72.5 ſilver,
15.5 copper,
12.0 carbonic acid.
100.0

SPECIES 2. Red ſilver ore (u).

191 Red ſilver ore.

This ore is very common in ſeveral German ſilver mines. It occurs in maſſes, diſſeminated and cryſtallized. The primitive form of its cryſtals is a dodecahedron ‡, whoſe ſides are equal rhombs, and which may be con-

* *Phil. Tranſ.* 1776, p. 532.

† *Kirwan*, ii. 110.

‡ *Romé de Liſle*, iii. 461.

§ *Hauy, Jour. de Min.* N° xxx. p. 473.

‖ *Kirwan, ibid.*

¶ *Opuſc.* ii. 415.

* *Jour. de Min. ibid.*

† *Beiträge*, ii. 301.

‡ *Kirwan*, ii. 115.

¶ *Cryſtal.* iii. 441.

* *Briſſon.*

† *Gellert.*

‡ *Beiträge*, i. 162.

* *Kirwan*, ii. 118.

† *Gellert.*

‡ *Beiträge*, i. 166.

* *Kirwan*, ii. 121.

† *Kirwan*, ii. 112.

‡ Fig. 38.

(u) *Kirw.* II. 122.—*Scopoli de Minera Argenti Rubra.*—*Sage, Jour. de Phyſ.* XXXIV. 331. and XLI. 370; and *Nouv. Jour. de Phyſ.* II. 284.—*Weſtrum, Jour. de Phyſ.* XLIII. 291.—*Klaproth, Beiträge*, I. 141.

conſidered as a ſix-ſided rhomboidal priſm, terminated by three-ſided ſummits *. Sometimes the priſm is lengthened, and ſometimes its edges, or thoſe of the terminating ſummits, or both, are wanting. For a deſcription and figure of theſe varieties, we refer to *De Liſle* † and *Hauy* ‡.

Its colour is commonly red. Streak red. External luſtre metallic, internal common. Tranſparency from 3 to 1; ſometimes opaque. Fracture flat conchoidal. Hardneſs 5 to 7. Brittle. Sp gr. from 5.44 § to 5.592 ¶. Becomes electric by friction, but only when inſulated ||. Soluble in nitric acid without effervеſcence *. Before the blow pipe melts, blackens, burns with a blue flame, gives out a white ſmoke with a ſlight garlic ſmell, and leaves a ſilver bead †.

Variety 1. Light red.

Colour intermediate between blood and cochineal red; ſometimes variegated. Streak orange red. Powder black.

Variety 2. Dark red.

Colour commonly between dark cochineal red and lead grey; ſometimes nearly black and without any ſhade of red. Streak dark crimſon red.

This ore was long ſuppoſed to contain arſenic. Klaproth firſt aſcertained its real compoſition ‡; and his analyſis has been confirmed by Vauquelin, who found a ſpecimen compoſed of

56.6748	ſilver,
16.1300	antimony,
15.0666	ſulphur,
12.1286	oxygen.
100.	

Klaproth proved, that the ſilver and antimony are in the ſtate of oxyds; and Vauquelin, that the ſulphur is combined partly with the oxyd of ſilver and partly with the oxyd of antimony. Klaproth obtained a little ſulphuric acid; but this acid, as Vauquelin, with his uſual ingenuity, demonſtrated, was formed during the analyſis.

This ore ſometimes contains a minute portion of arſenic, but never more than .02 *.

Genus IV. SALTS OF SILVER.

192 G. IV. Salts. Muriat of ſilver.

SPECIES 1. Muriat of ſilver (x).

Corneous ſilver ore.

This ore occurs at Johanngeorgenſtadt in Saxony, in South America, &c. It is often amorphous, ſometimes nearly in powder, and ſometimes cryſtallized in cubes or parallelopipeds.

Its colours are various: when expoſed to the light it becomes brown. Internal luſtre greaſy, 2; external, 2 to 1. Acquires a gloſs when ſcraped with a knife. Tranſparency 2 to 1. Texture foliated. Hardneſs 4 to 5. Sp. gr. 4.745 * to 4.804 †. Before the blowpipe it inſtantly melts, and gradually evaporates, but may be reduced by adding an alkali.

That this ore contains muriatic acid, has been long known. Mr Woulfe firſt ſhewed that it contained alſo ſulphuric acid ‡: and this diſcovery has been confirmed by Klaproth, according to whoſe analyſis this ore is compoſed of

67.75	oxyd of ſilver,
6.00	oxyd of iron,
21.00	muriatic acid,
.25	ſulphuric acid,
1.75	alumina.
96.75 ¶	

The alumina can only be conſidered as mixed with the ore. Sometimes its quantity amounts to .67 of the whole §.

ORDER III. ORES OF PLATINUM (Y).

193 Mines.

HITHERTO no mine of platinum has been diſcovered. It is found in ſmall ſcales or grains on the ſands of the river Pinto, and near Carthagena in South America. It is always in a metallic ſtate, and always combined with iron.

GENUS I. ALLOYS OF PLATINUM.

194 G. I. Alloys. Native platinum.

SPECIES 1. Native platinum.

Its colour is whitiſh iron grey. Magnetic. Sp. gr. from 12 to 16. Soluble in nitro-muriatic and oxymuriatic acids.

ORDER IV. ORES OF MERCURY.

MERCURY is employed in medicine; it ſerves to ſeparate ſilver and gold from their ores; the ſilvering of looking glaſſes, gilding, &c. are performed by means of it; and its ſulphuret forms a beautiful paint.

195 Mines.

Mercury abounds in Europe, particularly in Spain, Germany, and Hungary: it is found alſo in China (z), the Philippines *, and in Peru, and perhaps Chili (A) in South America. The moſt productive mines of mercury are thoſe of Idria †; of Almaden, near Cordova in Spain, which were wrought by the Romans (B); of the Palatinate ‡; and of Guanca Velica in Peru (C).

Mercury has never been found in Britain, nor has any mine worth working been diſcovered in France. It occurs moſt commonly in argillaceous ſhiſtus, limeſtones, and ſandſtones.

GENUS I. ALLOYS OF MERCURY.

196 G. I. Alloys. Native mercury.

SPECIES 1. Native mercury.

Native mercury is found in moſt mercurial mines: it is in ſmall globules, ſcattered through different kinds of ſtones, clays, and ores.

Fluid. Colour white. Sp. gr. about 13.6.

SPECIES

* *Romé de Liſle*, iii. 447.

† *Ibid.*

‡ *Jour. d'Hiſt. Naturelle*, N° 28. p. 216.

§ *Kirwan.*

¶ *Vauquelin, Jour. de Min*, N° xvii. p. 2.

|| *Hauy, ibid*, N° xxx. p. 476.

* *Hauy, ibid.* N° xxxi. p. 518.

† *Vauquelin, ibid.*

‡ *Ann. de Chim.* xviii. 81.

* *Vauquelin, ibid.* p. 8.

* *Briſſon.*

† *Gellert.*

‡ *Phil. Tranſ.* 1770.

¶ *Beiträge*, i. 134.

§ *Ibid.* p. 137.

* *Carreri's Voyage.*

† *Scopoli, Jour. de Min.* N° xxxvi. p. 915.

‡ *Jour. de Min.* Nos vi. and vii.

(x) *Kirw.* II. 113.—*Laxmann. Nov. Comm. Petropol.* XIX. 482.—*Monnet. Mem. Sçav. Etrang.* IX. 717.

(Y) See *Brownrigg, Phil. Tranſ.* XLVI. 584.—*Lewis, ibid.* XLVIII. 638. and L. 148.—*Margraf. Mem. Berlin*, 1757, p. 314.—*Macquer, Mem. Par.* 1758, p. 119.—*Buffon, Jour. de Phyſ.* III. 324.—*Morveau, ibid.* VI. 193.—*Bergman, Opuſc.* II. 166.—*Tillet, Mem. Par.* 1779, p. 373, and 385, and 545.—*Crell, Crell's Annals*, 1784, 1 *Band.* 328.—*Willis, Mancheſter Memoirs*, III. 467.—*Muſſin Puſchkin, Ann. de Chim.* XXIV. 205.—*Morveau, ibid.* XXV. 3.

(z) See *Entrecolle's Lettres Edificantes.*

(A) See *Molina's Natural Hiſtory of Chili.*

(B) See *Bowle's Natural Hiſtory of Spain*, and *Jour. de Min.* N° xxxi. p. 555.

(C) See *Ulloa's Memoirs concerning America.*

197 Amalgam of ſilver.

SPECIES 2. Amalgam of ſilver *.

Native amalgam.

This mineral has been found in the ſilver mine of Sahlberg†, in the province of Dalecarlia, in Sweden; in the mines of Deux Ponts‡, in the Palatinate; and in other places. It is in thin plates, or grains, or cryſtallized in cubes, parallelopipeds, or pyramids.

Its colour is ſilvery white or grey. Luſtre metallic. Creaks when cut. Sp. gr. above 10. Tinges gold white. Before the blow-pipe the mercury evaporates and leaves the ſilver.

* *Kirwan*, ii. 223.
† *Cronſtedt's Min.*
‡ *Heyer. Crell's Annals*, 1790.

A ſpecimen of this amalgam, analyſed by Klaproth, contained

contained	64 mercury,
	36 ſilver.
	100 §

§ *Beiträge*, i. 183.

Sometimes it contains a mixture of alumina, and ſometimes the proportion of mercury is ſo great that the amalgam is nearly as ſoft as paſte.

198 G. II. Sulphurets. Common ſulphuret.

GENUS II. SULPHURETS OF MERCURY.

SPECIES 1. Common ſulphuret *.

Native cinnabar.

This ore, which is found in almoſt all mercurial mines, is ſometimes in veins, ſometimes diſſeminated, ſometimes in grains, and ſometimes cryſtallized. The form of its cryſtals is a tetrahedron or three-ſided pyramid, moſt commonly wanting the ſummit; ſometimes two of theſe pyramids are joined baſe to baſe; and ſometimes there is a three-ſided priſm interpoſed between them †.

* *Kirwan*, ii. 228.
† *Romé de Liſle*, iii. 154.

Its colour is red. Its ſtreak red and metallic. Luſtre when cryſtallized 2 to 3; when amorphous, often 0. Tranſparency, when cryſtallized, from 1 to 3; when amorphous, often 0. Texture generally foliated. Hardneſs from 3 to 8. Sp. gr. from 5.419 to 10.1285.

Before the blow-pipe evaporates with a blue flame and ſulphureous ſmell. Inſoluble in nitric acid ‡.

Variety 1. Dark red.

Colour cochineal red. Hardneſs 6 to 7. Sp. gr. when pure, 10.1285 §; ſometimes only 7.2, or even 6.188 ¶.

Variety 2. Bright red.

Colour commonly ſcarlet. Sp. gr. 6.9022 † to 5.419 ‡.

‡ *Hauy, Jour. de Min.* N° xxxi. p. 518.
§ *Briſſon.*
¶ *Muſchenbroek.*
† *Briſſon.*
‡ *Gellert.*

199 G. III. Oxyds. Hepatic mercurial ore.

GENUS III. OXYDS OF MERCURY.

SPECIES 1. Hepatic mercurial ore*.

This ore, which is the moſt common in the mines of Idria, is always amorphous, and is often mixed with native mercury and cinnabar.

Its colour is ſomewhat red. Its ſtreak dark red and brighter. Luſtre commonly metallic. Hardneſs from 6 to 8. Sp. gr. from 9.2301 † to 7.186 ‡. When heated the mercury evaporates.

* *Kirwan*, ii. 224.
† *Briſſon.*
‡ *Kirwan.*

Though this ore has never been accurately analyſed, chemiſts have concluded that the mercury which it contains is in the ſtate of a red oxyd, becauſe it is inſoluble in nitric and ſoluble in muriatic acid ¶. When pureſt, it contains about .77 of mercury §. It contains alſo ſome ſulphur and iron.

Werner has divided this ſpecies into two varieties, the *compact* and the *ſlaty*. The ſecond is often nothing more than bituminous ſhale impregnated with oxyd of mercury †.

¶ *Sage, Jour. de Phyſ.* xxiv. 61.
§ *Scopoli, Jour. de Min.* N° xxxvi. p 919
† *Kirwan*, ii. 226.

200 Mercurial Salts. Muriat of mercury.

GENUS IV. MERCURIAL SALTS.

SPECIES 1. Muriat of mercury *.

Corneous mercury.

This ore, which occurs in the Palatinate, is ſometimes in ſcales, ſometimes in grains, and ſometimes cryſtallized. Its cryſtals are either ſmall four or ſix ſided priſms whoſe ſides are rhombs†, or cubes, or four-ſided pyramids wanting their angles. They are always very ſmall and generally confuſed.

Its colours are various; but it is moſt frequently white. Its luſtre, when white, is pearly. Sometimes opaque, and ſometimes ſemitranſparent. Evaporates before the blow-pipe.

* *Kirwan*, ii. 226.
† *Romé de Liſle*, iii. 161.

Mr Woulfe diſcovered, that this ore generally contains ſome ſulphuric acid ‡. Specimens have been found in which the quantity of ſulphuric acid exceeds that of the muriatic §.

‡ *Phil. Tranſ.* lxvi. 618.
§ *Suckow.*

ORDER V. COPPER ORES.

Many of the moſt uſeful utenſils are formed of copper: it enters largely into the compoſition of braſs, bronze, and bell metal; not to mention the dyes and paints of which it is the baſis.

201 Mines.

Copper mines abound in moſt countries. They are wrought in China, Japan, Sumatra; the north of Africa; in Chili and Mexico; and in moſt parts of Europe; eſpecially Britain, Germany, Ruſſia, Hungary.

Copper is found moſt commonly in rocks of hornblende, ſhiſtus, and quartz.

202 G. I. Alloys. Native copper.

GENUS I. ALLOYS OF COPPER.

SPECIES 1. Native copper *.

Native copper occurs now and then in the greater number of copper mines: Sometimes it is in maſſes, ſometimes in plates and threads, which aſſume a variety of forms; and ſometimes, as in Siberia, it is cryſtallized in cubes, or other forms nearly reſembling cubes †.

Colour commonly that of copper, but ſometimes dark brown. Luſtre metallic. Streak brighter. Fracture hackly. Flexible and malleable. Hardneſs 6 to 7. Sp. gr. from 7.6 ‡ to 8.5844 ¶.

* *Kirwan*, ii. 127.—*Carthenſer.*
† *Hauy, Jour. de Min* N° xxxi. 509.
‡ *Kirwan's Min.* ii. 128.
¶ *Hauy, ibid.* p. 509.

203 White copper ore.

SPECIES 2. White copper ore §.

Alloy of copper, iron, and arſenic.

This ore, which is ſaid to be uncommon, occurs in maſſes. Colour white. Luſtre metallic. Fracture uneven. Hardneſs 8 to 9. Brittle. Sp. gr. conſiderable.

Before the blow-pipe gives out a white arſenical ſmoke, and melts into a greyiſh black ſlag *.

§ *Kir. Min.* ii. 152.
* *Widenman.*

204 G. II. Sulphurets. copper. Common ſulphuret of copper.

GENUS II. SULPHURETS OF COPPER.

SPECIES 1. Common ſulphuret of copper †.

Vitreous copper ore.

This ore, which is found in Cornwal, Hungary, and Siberia, occurs in maſſes, plates, threads, and cryſtallized in ſix-ſided priſms, or four-ſided pyramids, joined baſe to baſe.

Colour bluiſh grey. Streak brighter grey. Luſtre metallic. Hardneſs 4 to 7. Sp. gr. 5.452 ‡ to 5.565 §; ſometimes ſo low as 4.129 *. Detonates with nitre.

† *Kirwan*, ii. 144.
‡ *Kirwan.*
§ *Gellert.*
* *Kirwan.*

Before the blow-pipe it melts eaſily; and while in fuſion exhibits a green pearl, which, on cooling, is covered with a brown cruſt. Tinges borax green.

Werner makes two varieties of this ore: the firſt he calls *compact*, from its fracture; and the ſecond, for the ſame reaſon, he calls *foliated*. This laſt is ſomewhat darker coloured than the firſt, but in other reſpects they agree.

205 Copper pyrites.

SPECIES 2. Copper pyrites*.

Yellow copper ore.

This ore, which is probably nothing elſe than ſulphuret of iron combined with copper, and which, therefore, would be more properly placed among iron ores, is found frequently in copper mines, and mixed with common pyrites or ſulphuret of iron. It is ſometimes amorphous, and ſometimes cryſtallized. Its cryſtals are either three or four ſided pyramids applied baſe to baſe, or ſix-ſided plates.

Its colour is yellow; often tarniſhed. Its internal luſtre metallic. Hardneſs 6 to 7; ſometimes 9. Brittle. Sp. gr. 4.314 † to 4.08 ‡. Deflagrates; but does not detonate with nitre ∥.

Before the blow-pipe decrepitates, gives a greeniſh ſulphureous ſmoke, and melts into a black maſs, which tinges borax green. Does not efferveſce with nitric acid.

206 Purple copper ore.

SPECIES 3. Purple copper ore *.

This ore is found in maſſes, or plates, or diſſeminated; ſometimes, alſo, it is cryſtallized in octohedrons. Colour various, but moſt commonly purple; internally reddiſh. Streak reddiſh and bright. Luſtre metallic. Hardneſs 6 to 7. Brittle. Sp. gr. 4.956 to 4.983 †.

Efferveſces with nitric acid, and tinges it green. Deflagrates with nitre. Before the blow-pipe melts readily, without ſmoke, vapour, or ſmell; but is not reduced. Tinges borax a bright green.

A ſpecimen of this ore, analyſed by Klaproth, contained

58 copper,
18 iron,
19 ſulphur,
5 oxygen.
—
100 ‡

207 Grey copper ore.

SPECIES 4. Grey copper ore §.

This ore is found in Cornwal, Saxony, Hungary, &c. It is often amorphous, but often alſo cryſtallized. The primitive form of its cryſtals is the regular tetrahedron; but, in general, either the angles or the edges, or both, are truncated or bevelled ∥.

Colour ſteel grey; often tarniſhed, and then dark grey. Streak dark grey; ſometimes reddiſh brown. Powder blackiſh; ſometimes with a tint of red. Luſtre metallic. Hardneſs 7 or 8. Very brittle. Sp. gr. 4.8648 *. Deflagrates with nitre. Before the blow-pipe crackles, but at laſt melts, eſpecially if aſſiſted by borax. The bead gives a white ſmoke, without any particular ſmell; tinges borax yellow or browniſh red, but does not unite with it.

A ſpecimen of this ore from Cremnitz, analyſed by Klaproth, contained

31 copper,
14 ſilver,
34 antimony,
3 iron,
11 ſulphur.
—
93

Napion, in an ore from the valley of Lanzo, found copper, ſilver, and antimony, nearly in the ſame proportions, but more iron, and ſome arſenic †. Savoreſi, as Baron Born informs us, beſides the ingredients of Klaproth's analyſis, found ſome gold and mercury in grey copper ore ‡: and Klaproth himſelf found lead in moſt of the other ſpecimens which he examined.

GENUS III. OXYDS OF COPPER.

208 G. III. Oxyds. Red oxyd of copper.

SPECIES 1. Red oxyd of copper §.

Florid red copper ore—Red copper glaſs.

This ore is found in Cornwal, and many other countries. It occurs in maſſes, diſſeminated, in ſcales, and cryſtallized. The figure of its cryſtals is moſt commonly the regular octohedron *.

Colour commonly cochineal red. Streak brick red. Luſtre ſemimetallic. Tranſparency, when amorphous, generally 0; when cryſtallized, 3 or 4. Hardneſs from 4 to 7. Soluble with efferveſcence in nitric acid. Before the blow-pipe melts eaſily, and is reduced.

This ore was ſuppoſed to be compoſed of carbonic acid and red oxyd of copper; but a ſpecimen, examined by Vauquelin, which conſiſted of pure cryſtals, contained no acid †. It muſt therefore be conſidered as an oxyd of copper.

Werner has made three varieties of this ore, which, from their texture, he has denominated *compact*, *foliated*, and *fibrous*. The firſt is ſeldom or never found cryſtallized, and is opaque; the ſecond occurs amorphous, cryſtallized, and in ſcales; the third is carmine, ruby, or ſcarlet red; and occurs always in ſhort capillary cryſtals, or delicate flakes.

This ore ſometimes contains a mixture of red oxyd of iron; it is then called *brick red copper ore*, *copper malm*, *or copper ochre*.

This ore is ſometimes mixed with bitumen. Its colour is then browniſh black, and it is called *pitch ore*.

209 Green oxyd of copper.

SPECIES 3. Green oxyd of copper §.

Green ſand of Peru.

This ore, which was brought from Peru by Dombey, is a graſs green powder, mixed with grains of quartz. When thrown on burning coals, it communicates a green colour to the flame. It is ſoluble both in nitric and muriatic acids without efferveſcence. The ſolution is green. It was ſuppoſed to contain muriatic acid *; but Vauquelin has diſcovered, that the appearance of this acid was owing to the preſence of ſome common ſalt, which is accidentally mixed with the ſand ‡.

GENUS IV. SALTS OF COPPER.

210 G. IV Salts. Blue carbonat of copper.

SPECIES 1. Blue carbonat of copper (D).

Mountain blue—Azur de cuivre—Blue calx of copper—Kupfer lazur.

This ore, which occurs in the copper mines of Siberia, Sweden, Germany, Hungary, Cornwal, &c. is either amorphous or cryſtallized. The cryſtals are ſmall, and difficult to examine. According to Romé de Liſle, their primitive form is an octohedron, the ſides of which are iſoſceles triangles, and two of them more inclined than the others §. Be that as it may, the cryſtals of blue carbonat of copper are often rhomboidal priſms, either regular, or terminated by dihedral ſummits *.

Its colour is azure or ſmalt blue. Streak blue. Hardneſs

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* Kirwan, ii. 140.

† Briſſon.

‡ Kirwan

∥ Id. Min. ii. 341.

* Kirwan, ii. 242.

† Ibid. ii. 243.

‡ Beiträge, ii. 286.

§ Kirwan, ii. 146.

∥ Romé de Liſle, iii. 315.

* Hauy, Jour. de Min. Nº xxxi. 512.

† Mem. Turin, v. 173.

‡ Catal. ii. 498.

§ Kirwan, ii. 135.

* Hauy, Jour. de Min. Nº xxxi. 517.

† Ibid.

§ Kirwan, ii. 149.

* Berthollet, Mem. Par. 1786, 462.

‡ Jour de Min. Nº xxxi. 519.

§ Cryſtal. iii. 343.

* Ibid. p. 345.

(D) *Kirw.* II. 129.—*Morveau, Mem. Dijon*, 1782. 1 *Semeſtre*, p. 100.

Copper Ores.

neſs 4 to 6. Brittle. Sp. gr. 3.608 ‡. It efferveſces with nitric acid, and gives it a blue colour. Before the blow-pipe it blackens, but does not melt. Tinges borax green with efferveſcences.

‡ Briſſon.

The cryſtals, according to Pelletier, are compoſed of
66 to 70 copper,
18 — 20 carbonic acid,
8 — 10 oxygen,
2 — 2 water.

Fontana firſt diſcovered that this ore contained carbonic acid gas.

Variety 1. Earthy blue carbonat.
Mountain blue.

This variety generally contains a mixture of lime. It is never cryſtallized; and ſometimes is almoſt in the ſtate of powder. Luſtre 0. Texture earthy.

Variety 2. Striated blue carbonat of copper.

Luſtre glaſſy. Tranſparency, when cryſtallized, 2; when amorphous, 1. Texture ſtriated; ſometimes approaching to the foliated.

211 Green carbonat of copper.

SPECIES 2. Green carbonat of copper (E).
Oxygenated carbonat of copper—Malachite.

This ore is generally amorphous, but ſometimes it is cryſtallized in four-ſided priſms, terminated by four-ſided pyramids.

Colour green. Luſtre ſilky. Hardneſs 5 to 7. Brittle. Sp. gr. 3.571 * to 3.653 ‡. Efferveſces with nitric acid, and gives a blue colour to ammonia. Before the blow-pipe it decrepitates and blackens, but does not melt. Tinges borax yellowiſh green. It is compoſed of carbonic acid and green oxyd of iron.

* Briſſon.
‡ Kirwan.

Variety 1. Fibrous malachite.

Texture fibrous. Opaque when amorphous; when cryſtallized its tranſparency is 2. Colour generally graſs green.

Variety 2. Compact malachite.

Texture compact. Opaque. Colour varies from the dark emerald green to blackiſh green.

A ſpecimen of malachite from Siberia, analyſed by Klaproth, contained
58.0 copper,
18.0 carbonic acid,
12.5 oxygen,
11.5 water.
———
100 *

* Beiträge, ii. 290.

This ſpecies is ſometimes mixed with clay, chalk, and gypſum, in various proportions; it is then known by the name of

Common mountain green.

Its colour is verdigris green. Luſtre 0. Tranſparency 0 to 1. Hardneſs 3 to 4. Brittle. Texture earthy. Efferveſces feebly with acids. Before the blow-pipe it exhibits the ſame phenomena with malachite.

212 Sulphat of copper.

SPECIES 3. Sulphat of copper.

For a deſcription of this ſalt, ſee CHEMISTRY, n° 648. in this *Supplement.*

213 Arſeniat of copper.

SPECIES 4. Arſeniat of copper ‡.
Olive copper ore.

‡ Kirwan, ii. 151.

This ore is found at Carrarach in Cornwal. It is generally cryſtallized in ſix-ſided compreſſed priſms. Its colour is olive green. Streak ſometimes ſtraw coloured, ſometimes olive green. Luſtre glaſſy. Tranſparency from 4 to 2. Fracture conchoidal. Hardneſs 4 to 7. Before the blow-pipe deflagrates with an arſenical ſmoke, and melts into a grey coloured bead. This bead, fuſed with borax, leaves a button of pure copper ‖.

Metallic Ores.

‖ *Klaproth's Obſervations on Cornwal,* p. 29.

Klaproth diſcovered that it was compoſed of oxyd of copper and arſenic acid.

Sometimes this ore is combined with iron. It then cryſtallizes in cubes. Theſe cubes are of a dark green colour; before the blow-pipe they froth, give out an arſenical ſmoke, and do not ſo quickly form a grey bead as the arſeniat of copper *.

* *Ibid.* p. 29.

ORDER VI. IRON ORES.

To deſcribe the uſes of iron, would be to write the hiſtory of every art and manufacture, ſince there is not one which is not more or leſs dependent upon this uſeful metal. Nor is its abundance inferior to its utility. It exiſts almoſt everywhere, and ſeems, as it were, the bond which connects the mineral kingdom together.

214 Mines.

GENUS I. ALLOYS OF IRON

215 G. I. Alloys. Native iron.

SPECIES 1. Native iron (F).

Native iron has been found in Siberia and in Peru in immenſe maſſes, which ſeemed as if they had been fuſed. Theſe maſſes evidently did not originate in the place where they were found. See *Fire-Balls, Suppl.*

Colour bluiſh white. Fracture hackly. Luſtre metallic. Malleable. Magnetic. Hardneſs 8 to 9. Sp. gr. 7.8. Prouſt has diſcovered, that the native iron found in Peru is alloyed with nickel ¶.

¶ *Nicholſon's Jour.* iii. 374.

GENUS II. SULPHURETS OF IRON.

SPECIES 1. Common ſulphuret of iron *.
Pyrites.

216 G. II. Sulphurets. Common ſulphuret of iron.

* *Kirwan,* ii. 76.—*Henkel's Pyritologia.*

This mineral occurs very frequently both in ores and mixed with other bodies, for inſtance in ſlates. It is often amorphous, and often alſo cryſtallized. The primitive form of its cryſtals is either a regular cube or an octohedron. The varieties of its form hitherto deſcribed amount to 30; for a deſcription of which we refer the reader to *Romé de Liſle* †.

† *Cryſtal.* iii. 208.

Its colour is yellow. Its luſtre metallic. Hardneſs 8 to 10. Brittle. Sp. gr. 3.44 to 4.6. Soluble in nitric acid with efferveſcence. Scarce ſoluble in ſulphuric acid. Before the blow-pipe burns with a blue flame and a ſulphureous ſmell, and leaves a browniſh bead, which tinges borax of a ſmutty green.

Variety 1. Common pyrites.

Fracture uneven Hardneſs 10. Decrepitates when heated. Emits a ſulphureous ſmell when rubbed. Not magnetic. It occurs often in coal mines and in ſlates.

Variety 2. Striated pyrites.

Texture ſtriated. Hardneſs 10. Not magnetic.

Variety 3. Capillary.

Colour often ſteel grey. Found in needle-form cryſtals. Uncommon. Not magnetic.

Variety 4. Magnetic pyrites.

Found in maſſes. Texture compact. Hardneſs 8, 9. Slightly magnetic. Seems to contain leſs ſulphur than the other varieties.

In pyrites the proportion of the ſulphur to the iron is variable, and this explains the variety of its cryſtalline forms.

GENUS

(E) *Kirw.* II. 131.—*Fontana, Jour. de Phyſ.* XI. 509.—*Klaproth, Beiträge,* II. 287.

(F) *Pallas, Phil. Tranſ.* LXVI. 523.—*Rubin de Celis, ibid.* LXXVIII. 37.—See alſo *Schreiber, Jour. de Phyſ.* XLI. 3.; and *Stelin, Phil. Tranſ.* LXIV. 461.

217
G. III.
Plumbago.

GENUS III. CARBURET OF IRON.

SPECIES 1. Plumbago *.

Graphite of Werner.

This mineral is found in England, Germany, France, Spain, America, &c. It occurs in kidney-form lumps of various ſizes. Its colour is dark iron grey or browniſh black; when cut, bluiſh grey. Luſtre metallic, from 3 to 4. Opaque. Structure ſlaty. Texture fine grained. Hardneſs 4 to 5. Brittle. Sp. gr. from 1.987 to 2.089; after being ſoaked in water 2.15; after being heated 2.3, and when heated after that 2.41 †. Feels ſomewhat greaſy. Stains the fingers, and marks ſtrongly. The uſe of this mineral when manufactured into pencils is known to every perſon.

Its compoſition was diſcovered by Scheele. When pure it contains

90	carbon,
10	iron.
100	

But it is often exceedingly impure: A ſpecimen, for inſtance, from the mine of Pluſſier, in France, analyſed by Vauquelin, contained

23	carbon,
2	iron,
38	ſilica,
37	alumina.
100 ‡	

218
G. IV.
Emery.

GENUS IV. IRON COMBINED WITH SILICA.

SPECIES 1. Emery *.

This mineral is commonly diſſeminated through other foſſils, but ſometimes in the Eaſt Indies it occurs in large maſſes.

Its colour is bluiſh grey, greyiſh brown, or bluiſh black, often covered with a yellowiſh rind; internally it diſcovers red or purple ſpots. Luſtre 1 or 0; in ſome parts 2, and metallic. Opaque. Hardneſs 14. Brittle. Sp. gr. 3.92 †. Before the blow pipe it blackens and gives a ſmutty yellow tinge to borax.

According to Wiegleb it contains

95.6	ſilica,
4.3	iron.
99.9	

219
G. V.
Oxyds.

GENUS V. OXYDS OF IRON.

This genus is very extenſive; for iron is much more frequently found in the ſtate of an oxyd than in any other.

220
Black oxyd of iron.

SPECIES 1. Black oxyd of iron ‡.

Common magnetic iron ſtone—Blackiſh octohedral iron ore.

This ſpecies of ore is very common in Sweden; it is found alſo in Switzerland, Norway, Ruſſia, &c. It occurs in maſſes, plates, grains, and cryſtallized. The primitive form of its cryſtals is a regular octohedron †. Sometimes two oppoſite ſides of the pyramids are trapeziums, which renders the apex of the pyramids cuneiform. Sometimes the cryſtals paſs into rhomboidal parallelopipeds, and into dodecahedrons with rhomboidal faces §.

Its ſurface is browniſh black; internally bluiſh grey. Powder black *. Streak blackiſh grey, brighter. Luſtre metallic. Hardneſs 9 to 10. Brittle. Sp. gr. from 4.094 to 4.688 †. Attracted by the magnet, and generally poſſeſſed of more or leſs magnetic virtue ‡. To this ſpecies belongs the magnet. Before the blow-pipe it becomes browner, but does not melt. Tinges borax dark green.

When pure it conſiſts entirely of oxyd of iron; and this oxyd appears to contain from .15 to .24 oxygen, and from .76 to .85 iron §. Undoubtedly it conſiſts of a mixture of iron in two different ſtates of oxydation. It is often alſo mixed and contaminated with foreign ingredients.

There are two varieties of this ore. The firſt is what we have juſt deſcribed; the ſecond is in the form of ſand, and has therefore been called

Magnetic ſand *.

This ſubſtance is found in Italy, Virginia, St Domingo, the Eaſt Indies, and in the ſand of the river Don at Aberdeen in Scotland. It is black, very hard, magnetic. Sp. gr. about 4.6. Not altered by the blow-pipe *per ſe*; melts into a black glaſs with potaſs, and into a green glaſs with microcoſmic ſalt, both opaque †. It probably contains ſome ſilica, as Kirwan has ſuppoſed ‡.

221
Specular iron ore.

SPECIES 2. Specular iron ore ¶.

Fer oligiſte.

This ore is found abundantly in the iſle of Elba near Tuſcany. It is either in maſſes or cryſtallized. The primitive form of its cryſtals, and of its integrant molecules, is the cube *. The varieties hitherto obſerved amount to 7. Theſe are the rhomboidal parallelopiped; the cube, with three triangular faces inſtead of two of its angles diagonally oppoſite; two ſix-ſided pyramids, applied baſe to baſe, wanting the ſummits ‡, and ſometimes the angles at the baſes, and ſometimes the alternate edges of the pyramid; a polyhedron of 24 ſides, reſembling a cube with three triangular faces for two angles diagonally oppoſite, and two triangles for the reſt of its angles. For a deſcription and figure of theſe varieties, we refer to *Romé de Liſle* † and *Hauy* ‡.

Colour ſteel grey; often tarniſhed, and beautifully irideſcent, reflecting yellow, blue, red. Streak red. Powder dark red. Luſtre metallic. Hardneſs 9 to 10. Not brittle. Sp. gr. 5.0116 † to 5.218 ‡. Slightly magnetic. Little altered by the blow-pipe. Tinges borax an obſcure yellow.

This ore, according to Mr Muſhet, is compoſed of

66.1	iron,
21.2	oxygen,
10.7	water and carbonic acid,
2.0	lime.
100.0 †	

The quantity of oxygen here ſtated is probably too ſmall, owing to the unavoidable inaccuracy which reſults from the *dry way* of analyſis which Mr Muſhet followed.

Micaceous iron ore

Is generally conſidered as a variety of this ſpecies. Kirwan, however, ſuppoſes it to contain carbon, and to be a diſtinct ſpecies.

It is found in Saxony, and in the Iſle of Elba, &c. generally in amorphous maſſes, compoſed of thin ſix-ſided laminæ. Colour iron grey. Streak bluiſh grey. Luſtre metallic. Opaque. Feel greaſy. Hardneſs 5 to 7. Brittle. Sp. gr. from 4.5 to 5.07. Slightly magnetic.

Plumbago: * Kirwan, ii. 58.

† Briſſon.

‡ Jour. de Min. N° xii. p. 16.

Emery: * Kirwan, ii. 193.

† Briſſon.

Black oxyd of iron: ‡ Kirwan, ii. 158.

† Romé de Liſle, iii. 178.

§ Ibid.

* Hauy, Jour. de Min. N° xxxiii. 659.

† Kirwan's Min. ii. 159.

‡ Hauy, Jour. de Min. N° xxxi. 527.

§ Kirwan Min. ii. 159.

Magnetic ſand: * Kirwan, ii.—Dupuget, Jour. de Min. N° xxi. p. 75.

† Fourcroy, Ann. de Chim ii. 127.

‡ Min. ii. 161.

Specular iron ore: ¶ Kirw ii. 162—Cordrai, Jour. de Phyſ. iv. 52.

* Hauy, Jour. de Min. N° xxviii. 660.

‡ Fig. 39.

† Cryſt. iii. 189.

‡ Ibid 662.

† Hauy.

‡ Briſſon.

† Philoſ. Mag. iii. 354.

magnetic. Infuſible by the blow-pipe. Tinges borax greeniſh brown.

222 Laminated ſpecular iron ore.

SPECIES 3. Laminated ſpecular iron ore.

Fer pyrocete of Hauy.

This ore, which is found at Montd'or in Auvergn, was uſually arranged under the laſt ſpecies; but has been ſeparated from it, we think properly, by Mr Hauy, becauſe the form of its cryſtals is incompatible with the ſuppoſition that their primitive nucleus is a cube, as we have ſeen is the caſe with common ſpecular iron ore. Its cryſtals are thin octagonal plates, bounded by ſix linear trapeziums, alternately inclined different ways[†].

Colour ſteel grey. Powder reddiſh black. Luſtre metallic; ſurface poliſhed. Fracture glaſſy. Very brittle[‡]. Hauy ſuppoſes that this ore has been produced by fire, and accordingly has given it a name which denotes its origin.

223 Brown iron ore.

SPECIES 4. Brown iron ore[¶].

This ſpecies of ore is found abundantly in Britain, particularly in Cumberland and Lancaſhire; and it is alſo very common in other counties. It conſiſts of the brown oxyd of iron, more or leſs contaminated with other ingredients.

Its colour is brown. Its ſtreak reddiſh brown. Sp. gr. from 3.4771 to 3.951. Before the blow-pipe blackens, but does not melt. Tinges borax greeniſh yellow.

Variety 1. Brown hæmatites.

The name hæmatites (bloodſtone) was probably applied by the ancients only to thoſe ores which are of a red colour, and have ſome reſemblance to clotted blood; but by the moderns it is applied to all the ores of iron which give a reddiſh coloured powder, provided they be of a fibrous texture.

Brown hæmatites occurs in maſſes of various ſhapes, and it is ſaid alſo to have been found cryſtallized in five or ſix ſided acute angled pyramids. Colour of the ſurface brown or black, ſometimes irideſcent; internally nut brown. Powder red. Texture fibrous. Hardneſs 8 to 10. Brittle. Sp. gr. 3.789[†] to 3.951[‡]. Not magnetic.

This variety has not been analyſed, but it ſeems to conſiſt of brown oxyd of iron, oxyd of manganeſe, and alumina[¶].

Variety 2. Compact brown iron ſtone.

This variety occurs in maſſes of very various and often fantaſtical ſhapes.

Colour brown. Internal luſtre metallic. Texture compact. Hardneſs 6 to 9. Brittle. Sp. gr. 3.4771[†] to 3.551[‡].

Variety 3. Brown Scaly iron ore.

This variety is generally incumbent on other minerals. Colour brown. Luſtre metallic. Stains the fingers, marks ſtrongly. Feels unctuous. Texture foliated. Hardneſs 3 to 5. Brittle. So light as often to float on water.

Variety 4. Brown iron ochre.

This variety occurs both maſſive and diſſeminated. Colour from nut brown to orange. Luſtre 0. Strongly ſtains the fingers. Texture earthy. Hardneſs 3 to 4. When ſlightly heated reddens.

224 Red iron ore.

SPECIES 5. Red iron ore[†].

Colour red. Streak blood red. Sp. gr. from 3.423 to 5.005. Before the blow pipe blackens, but does not melt. Tinges borax yellowiſh olive green. When digeſted in ammonia, it becomes black and often magnetic.

Variety 1. Red hæmatites.

Found in maſſes, and all the variety of forms of ſtalactites. Colour between browniſh red and ſteel grey. Powder red. Internal luſtre metallic. Texture fibrous. Hardneſs 9 to 10. Brittle. Sp. gr. 4.74[†] to 5.005[‡].

When pure it conſiſts of red oxyd of iron, but it often contains manganeſe and alumina[§].

Variety 2. Compact red iron ore.

Found maſſive and ſtalactitic; ſometimes in cryſtals of various forms, but they ſeem to be only ſecondary; ſometimes in columns like baſalt.

Colour between brown red and ſteel grey. Stains the fingers. Luſtre 1 to 0; often ſemimetallic. Texture compact. Hardneſs 7 to 9. Brittle. Sp. gr. 3.423 to 3.76[†] Sometimes inveſted with a roſy red ochre.

Variety 3. Red ochre.

Found ſometimes in powder, ſometimes indurated. Colour blood red. Stains the fingers. Luſtre 0. Texture earthy. Hardneſs 3 to 5. Brittle.

Variety 4. Red ſcaly iron ore.

This variety is generally found incumbent upon other iron ores. Colour between cherry red and ſteel grey. Stains the fingers. Luſtre ſilky, inclining to metallic. Texture foliated. Feels unctuous. Hardneſs 3 to 4. Brittle. Heavy.

225 Argillaceous iron ore.

SPECIES 6. Argillaceous iron ore[†].

Oxyd of iron combined or mixed with clay.

This ore is exceedingly common; and though it contains leſs iron than the ſpecies already deſcribed, it is, in this country at leaſt, preferred to them, becauſe the method of extracting pure iron from it is eaſier, or rather becauſe it is better underſtood.

Colour moſt commonly dark brown. Streak red or yellowiſh brown. Sp. gr. from 2.673 to 3.471[‡]. Before the blow-pipe blackens, and tinges borax olive green and blackiſh. It is compoſed of oxyd of iron, alumina, lime, ſilica in various proportions. It generally yields from 30 to 40 *per cent.* of iron.

Variety 1. Common argillaceous iron ore.

The minerals arranged under this variety differ conſiderably from each other in their external characters: They are found in maſſes of various ſhapes, and often form large ſtrata.

Colour various ſhades of grey, brown, yellow, and red. Streak reddiſh yellow or dark red. Luſtre 0. Hardneſs from 3 to 8. Smell earthy when breathed upon.

Variety 2. Columnar or ſcapiform iron ore.

This variety is found in columns, adhering to each other, but eaſily ſeparable: They are commonly incurvated, and their ſurface is rough. Colour browniſh red. Streak dark red. Slightly ſtains the fingers. Luſtre 0. Adheres ſtrongly to the tongue. Sound hollow. Feels dry. Texture earthy.

Variety 3. Acinoſe iron ore.

This variety is found in maſſes, and is commonly lenticular. Colour generally browniſh red. Luſtre metallic, nearly. Texture granular. Hardneſs 5 to 9. Brittle.

[†] *De Liſle*, iii. 188.

[‡] *Hauy, Jour. de Min.* N° xxxi. 33.

[¶] *Kirw.* ii. 163.

[†] *Gellert.*

[‡] *Kirwan.*

[¶] *Kirwan's Min.* ii. 164.

[†] *Briſſon.*

[‡] *Kirwan.*

[†] *Kirw.* ii. 168.

[†] *Gellert.*

[‡] *Kirwan.*

[§] *Kirwan's Min.* ii. 169.

[†] *Kirwan.*

[†] *Kirw.* ii. 173.

[‡] *Kirwan.*

Variety 4. Nodular, or kidney-form iron ore.
Ætites or *Eagleſtone.*

This variety, which was mentioned by the ancients, is generally found under the form of a rounded knob, more or leſs reſembling a kidney, though ſometimes it is quadrangular; and it contains within it a kernel, which is ſometimes looſe, and ſometimes adheres to the outſide rind. Colour of the ſtone yellowiſh brown; of the kernel ochre yellow. Surface generally fouled with earth. Luſtre of the rind metallic; of the kernel 0. Hardneſs from 4 to 7. Brittle.

Variety 5. Piſiform or granular iron ore.

This variety occurs in rounded maſſes, from the ſize of a pea to that of a nut. Surface rough. Colour commonly dark brown. Streak yellowiſh brown. Hardneſs 5 to 6. Brittle.

The oolitic ore found at Creuſot, near mount Cenis, belongs to this variety. It is compoſed of

50 lime,
30 iron,
20 alumina.
——
100

226 Lowland iron ore. SPECIES 7. Lowland iron ore *.

This ſpecies of ore is ſuppoſed to conſiſt of oxyd of iron, mixed with clay and phoſphuret or phoſphat of iron. It is called lowland ore, becauſe it is found only in low grounds; whereas the laſt ſpecies is more commonly in high grounds; and is therefore called *highland ore*.

This ore occurs in amorphous maſſes, and alſo in grains or powder. Its colour is brown. Streak yellowiſh brown. Luſtre 0, or common. Texture earthy. Hardneſs 3 to 5.

Variety 1. Meadow lowland ore.

Colour blackiſh or yellowiſh brown: Both colours often meet in the ſame ſpecimen. Found in lumps of various ſizes, often perforated. Fracture compact. Moderately heavy.

Frequently yields from 32 to 38 *per cent.* of iron.

Variety 2. Swampy iron ore.

This variety is generally found under water. It is in lumps, which are commonly perforated or corroded, and mixed with ſand. Colour dark yellowiſh brown, or dark nut brown. Hardneſs 3 to 4. Brittle. Sp. gr. 2.944. It often contains .36 of iron.

Variety 3. Moraſſy iron ore.

This variety is found either in a looſe form or in perforated lumps. Colour light yellowiſh brown. Stains the fingers. Hardneſs 3. Friable.

227 G.VI. Salts. Sparry iron ore. GENUS VI. SALTS OF IRON.

SPECIES 1. Sparry iron ore (G).

This ore is common in Germany, France, and Spain. It is found ſometimes in amorphous maſſes, and ſometimes cryſtallized.

Its colour is white; but it becomes tarniſhed by expoſure to the air, and then aſſumes various colours. Streak grey or white. External luſtre often metallic; internal common or glaſſy. Tranſparency 1 or 2; ſometimes 0. Texture foliated. Fragments rhomboidal. Hardneſs 5 to 7. Brittle. Sp. gr. 3.6 to 3.810. Not magnetic. Soluble in acids with very little efferveſcence. Before the blow-pipe decrepitates, becomes browniſh black, and magnetic; but is ſcarcely fuſible. Tinges borax ſmutty yellow, with ſome efferveſcence.

This ore, as Bergman aſcertained, conſiſts of iron, manganeſe, lime, and carbonic acid.

One ſpecimen, according to his analyſis, contained

38 iron,
24 manganeſe,
38 carbonat of lime.
——
100

Another contained 22 iron,
28 manganeſe,
50 carbonat of lime.
——
100

Whether the iron be combined with the carbonic acid is ſtill a diſputed point. The cryſtals of this ore are rhomboidal parallelopipeds; which is preciſely the form of carbonat of lime. This amounts nearly to a demonſtration, that the carbonic acid is combined with the lime; and that, as Cronſtedt and Hauy have ſuppoſed, this ore is merely carbonat of lime, contaminated with a quantity of the oxyds of iron and manganeſe.

228 Arſeniat of iron. SPECIES 2. Arſeniat of iron.

Mr Prouſt has diſcovered this ore in Spain. Its colour is greeniſh white. Its texture granular. Inſoluble in water and nitric acid. When melted on charcoal, the arſenical acid eſcapes with efferveſcence ‡.

229 Sulphat of iron. SPECIES 3. Sulphat of iron.

For a deſcription of this ſalt, ſee CHEMISTRY, n° 631. in this *Suppl.*

ORDER VII. TIN ORES (H).

TIN is employed to cover plates of iron and copper, and to ſilver the backs of looking glaſſes: It enters into the compoſition of pewter; and forms a very important article in dyeing.

230 Mines. Tin ores are by no means ſo common as the ores of the metals which we have already deſcribed. They are found only in the *primitive mountains* (I). Hence Werner ſuppoſes them to be the moſt ancient of all metallic ores. They occur moſt frequently in granite, ſometimes in porphyry, but never in limeſtone.

Almoſt

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* *Kirw.* ii. 179.

‡ *Ann. de Chim.* i. 195.

(G) *Kirw.* II. 190.—*Bergman*, II. 184.—*Bayen. Jour. de Phyſ.* VII. 213.—*Razowmowſki, Mem. Lauſanne*, 1783, p. 149.

(H) *Geoffroy, Mem. Par.* 1738, p. 103.—*Morveau, Ann. de Chim.* XXIV. 127.

(I) Geologiſts have divided mountains into three claſſes; *primitive*, *ſecondary*, and *tertiary*. The *primitive* occupy the centre of all extenſive chains; they are the higheſt, the moſt rugged, and exhibit the moſt pointed tops. They are conſidered as the moſt ancient mountains of the globe.

The *ſecondary* mountains occupy the outſide of extenſive ranges. They are uſually compoſed of ſtrata, more or leſs inclined, and commonly reſt againſt the ſides of the primitive mountains.—The *tertiary* mountains are much ſmaller than the others, and are often ſolitary. We uſe the terms *primitive*, *ſecondary*, &c. merely as

proce

Tin Ores.

Almoſt the only tin mines known to Europeans are thoſe of Cornwal, Devonſhire, Saxony, Bohemia, Sileſia, Hungary, Gallicia; thoſe of the iſland of Bauca and the peninſula of Malacca in India; and thoſe of Chili and Mexico in America.

231
G. I. Sulphurets. Sulphuret of tin and copper.

GENUS I. SULPHURETS OF TIN.

SPECIES I. Sulphuret of tin and copper *.

Tin pyrites.

Hitherto this ore has only been found in Cornwal. There is a vein of it in that county, in the pariſh of St Agnes, nine feet wide, and twenty yards beneath the ſurface †.

Its colour is yellowiſh grey, paſſing into the ſteel grey. Not unlike grey copper ore. Luſtre metallic. Hardneſs 5 to 6. Very brittle. Sp. gr. 4.35 ‡. Before the blow-pipe it melts eaſily, with a ſulphureous ſmell, into a black bead, and depoſits a bluiſh oxyd on the charcoal.

The compoſition of this ore, as Klaproth informs us, was firſt diſcovered by Mr Raſpe. According to Klaproth's analyſis, it is compoſed of

34 tin,
36 copper,
25 ſulphur,
3 iron,
2 earth.

100 §

232
G. II. Oxyds. Brown oxyd of tin.

GENUS II. OXYDS OF TIN.

SPECIES I. Brown oxyd of tin *.

Tinſtone—Woodtin.

This ore, which may be conſidered as almoſt the only ore of tin, occurs in maſſes, in rounded pieces, and cryſtallized. Theſe cryſtals are very irregular. Hauy ſuppoſes, that their primitive form is a cube †; but Romé de Liſle, with more probability, makes it an octohedron ‡; and in this opinion Mr Day agrees with him ‖. The octohedron is compoſed of two four-ſided pyramids, applied baſe to baſe. The ſides of the pyramids are iſoſceles triangles, the angle at the vertex of which is 70°, and each of the other angles 55°. The ſides of the two pyramids are inclined to each other at an angle of 90° §. This primitive form, however, never occurs, but cryſtals of tinſtone are ſometimes found, in which the two pyramids are ſeparated by a priſm. For a complete deſcription of the varieties of the cryſtals of tinſtone, we refer the reader to *Romé de Liſle* and *Mr Day* *.

Metallic Ores.

Its colour is commonly brown. Streak grey. Hardneſs 9 to 10. Sp. gr. 6.9 to 7.0. Brittle.

Variety 1. Common tinſtone.

Colour dark brown; ſometimes yellowiſh grey, and ſometimes nearly white. Streak light grey. Somewhat tranſparent when cryſtallized. Hardneſs 10. Sp. gr. 6.9 to 6.97. Before the blow-pipe it decrepitates, and on charcoal is partly reduced. Tinges borax white.

According to Klaproth, it is compoſed of

77.50 tin,
21.50 oxygen,
.25 iron,
.75 ſilica.

100.00 †

Variety 2. Woodtin.

This variety has hitherto been found only in Cornwal. It occurs always in fragments, which are generally rounded. Colour brown; ſometimes inclining to yellow. Streak yellowiſh grey. Opaque. Texture fibrous. Hardneſs 9. Sp. gr. 7.0. Before the blow-pipe becomes browniſh red; decrepitates when red hot, but is not reduced.

Klaproth obtained from it .63 of tin; and, in all probability, it is an oxyd of tin nearly pure.

ORDER VIII. ORES OF LEAD.

THE uſeful purpoſes to which lead in its metallic ſtate is applied, are too well known to require deſcription. Its oxyds are employed in painting, in dyeing, and ſometimes alſo in medicine.

Ores of lead occur in great abundance in almoſt every part of the world. They are generally in veins; ſometimes in ſiliceous rocks, ſometimes in calcareous rocks.

233
G. I. Sulphurets. Galena, or pure ſulphuret of lead.

GENUS I. SULPHURETS OF LEAD.

SPECIES I. Galena, or pure ſulphuret of lead ‡.

This ore, which is very common, is found both in maſſes and cryſtallized. The primitive form of its cryſtals is a cube. The moſt common varieties are the cube, ſometimes with its angles wanting, and the octohedron, compoſed of two four-ſided pyramids applied baſe to baſe: The ſummits of theſe pyramids are ſometimes cuneiform, and ſometimes their ſolid angles are wanting ‖.

Its colour is commonly bluiſh grey, like lead. Streak bluiſh grey and metallic. Luſtre metallic. Sometimes ſtains

* Kirw. ii. 200.

† Klaproth's Cornwall, p. 21.

‡ Klaproth.

§ Id. 58.

* Kirw. ii. 297.

† Jour. de Min. N° xxxii. 576.

‡ Cryſtallog. iii. 413.

‖ Philoſ. Mag. iv. 152.

§ Romé de Liſle, ibid.

* Philoſ. Mag. ibid.

† Beiträge, ii. 256.

‡ Kirw. ii. 216.

‖ Romé de Liſle, iii. 364.

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proper names, without affirming or denying the truth or falſehood of the theory on which theſe names are founded. That the reader may have a more accurate idea of the compoſition of theſe different claſſes of mountains, we have ſubjoined a liſt of the ſubſtances which, according to Werner, enter into the compoſition of each.

I. PRIMARY MOUNTAINS.

1. Granite,
2. Gneiſs,
3. Micaceous ſhiſtus
4. Argillaceous ſhiſtus,
5. Syenite,
6. Porphyry,
7. Shiſtoſe porphyry,
8. Quartz,
9. Primitive limeſtone,
10. Serpentine,
11. Topaz rock.

II. SECONDARY MOUNTAINS.

1. Argillaceous ſhiſtus,
2. Rubble ſtone,
3. Secondary limeſtone,
4. Shiſtoſe hornblende,
5. Grunſtein,
6. Amygdaloid.

III. TERTIARY MOUNTAINS.

1. Trap,
2. Argillaceous ſhiſtus,
3. Stratified limeſtone,
4. Sandſtone,
5. Breccia,
6. Coal,
7. Chalk,
8. Sulphat of lime,
9. Rock ſalt,
10. Ferruginous clay,
11. Potters earth.

ſtains the fingers. Texture foliated. Fragments cubical. Hardneſs 5 to 7; ſometimes even 9. Brittle. Sp. gr. 6.884 to 7.786 §. Efferveſces with nitric and muriatic acids. Before the blow-pipe decrepitates, and melts with a ſulphureous ſmell; part ſinks into the charcoal.

§ *Watſon.*

It is compoſed of from .45 to .83 lead, and from .086 to .16 of ſulphur. It generally contains ſome ſilver, and ſometimes alſo antimony aud zinc.

Variety 1. Common galena.

This variety correſponds nearly with the above deſcription. Sp. gr. 7.051 to 7.786. Sometimes ſtains the fingers.

Compact galena.

Found only in amorphous maſſes. Texture compact, inclining to foliated. Hardneſs 6 to 8. Sp. gr. 6.886 to 7.444. Luſtre common. Streak lead grey, brighter and metallic. Often feels greaſy, and ſtains the fingers.

234 Sulphuret of lead, with ſilver and antimony.

SPECIES 2. Sulphuret of lead, with ſilver and antimony*.

Plumbiferous antimoniated ſilver ore.

Found in amorphous maſſes. Colour grey. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.2 to 8.

* *Kirw.* ii. 119.

Variety 1. Light grey ſilver ore.

Colour light bluiſh grey. Streak light bluiſh grey, and brighter. Luſtre metallic. Texture compact. Before the blow pipe partly evaporates, and leaves a ſilver bead on the charcoal, ſurrounded by yellow duſt.

According to Klaproth, it contains

48.06 lead,
20.40 ſilver,
7.88 antimony,
12.35 ſulphur,
2.25 iron,
7.00 alumina,
.25 ſilica.

98.09 †

† *Beiträge,* i. 172.

Variety 2. Dark grey ſilver ore.

Colour iron grey, verging on black. Powder black, and ſtains the fingers. Luſtre 0. Texture earthy.

According to Klaproth, it contains

41.00 lead,
21.50 antimony,
29.25 ſilver,
22.00 ſulphur,
1 75 iron,
1.00 alumina,
.75 ſilica.

97.25 ‡

‡ *Ibid.* 175.

235 Blue lead ore.

SPECIES 3. Blue lead ore*.

* *Kirw.* ii. 220.

This ore, which is found in Siberia, Germany, and Hungary, and is very rare, occurs ſometimes in maſſes, and ſometimes cryſtallized in ſix-ſided priſms.

Colour between indigo blue and lead grey; ſometimes inclining to black. Internal luſtre metallic. Streak brighter. Texture compact. Hardneſs 6. Sp. gr. 5.461 †. Before the blow pipe melts with a low blue flame and a ſulphureous ſmell, and is eaſily reduced.

† *Gellert.*

236 Black lead ore.

SPECIES 4. Black lead ore ‡.

‡ *Kirw.* ii. 221.

This ore, which is found in Germany and Brittanny, and which is ſuppoſed to be common galena decayed, is ſometimes in ſtalactites of various forms, and ſometimes cryſtallized in ſix-ſided priſms, which are generally truncated and confuſed.

Colour black, often with ſome ſtreaks of red. Streak light bluiſh grey. Internal luſtre metallic. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.744 ‖ to 5.77 *. Before the blow-pipe decrepitates, melts eaſily, and is reduced.

‖ *Briſſon.*
* *Gellert.*

According to the experiments of Laumont, this ore is a ſulphuret of lead (or rather ſulphuret of oxyd of lead), mixed with ſome phoſphat of lead.

237 Sulphuret of lead, biſmuth, and ſilver.

SPECIES 5. Sulphuret of lead, biſmuth, and ſilver.

This ore, which occurs in the valley of Schapbach in Saxony, was firſt taken notice of by Selb, and afterwards deſcribed by Weidenmann and Emerling.

Its colour is light bluiſh grey. Its luſtre metallic. Its fracture uneven. Hardneſs 5. Melts eaſily before the blow pipe, emitting ſome ſmoke, and leaves a ſilver bead.

A ſpecimen, analyſed by Mr Klaproth, contained

33.0 lead,
27.0 biſmuth,
15.0 ſilver,
16.3 ſulphur,
4.3 iron,
0.9 copper.

96.5 †

† *Beiträge,* ii. 297.

238 G. II. Oxyds. Lead ochre.

GENUS II. OXYDS OF LEAD.

SPECIES 1. Lead ochre ‡.

This ore, which is a mixture of the oxyd of lead with various earths, is found maſſive, and of various degrees of hardneſs.

‡ *Kirw.* ii. 205.

Its colour is either yellow, grey, or red. Luſtre 0. Tranſparency 0 to 1. Hardneſs 6 to 8; ſometimes in powder. Sp. gr. from 4.165 to 5.545 §. Texture compact. Efferveſces with nitric and muriatic acids. Eaſily reduced by the blow-pipe, leaving a black ſlag, unleſs the lead be mixed with too great a proportion of earth.

§ *Kirwan.*

239 G. III. Salts. Carbonat of lead.

GENUS III. SALTS OF LEAD.

SPECIES 1. Carbonat of lead ‡.

White lead ſpar.

This ore of lead, which is very common, is ſometimes in maſſes, and ſometimes cryſtallized. But the cryſtallization is in general ſo confuſed, that the primitive form of the cryſtals has not yet been aſcertained (K).

‡ *Kirw.* ii. 203.

Its colour is white. External luſtre, waxy or ſilky, from 3 to 1; internal 1 to 2. Generally ſomewhat tranſparent. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.349 ‖ to 6.92 §. Efferveſces with nitric and muriatic acids when they are heated. Soluble in fat oils. Blackened by ſulphuret of ammonia *. Decrepitates when heated. Before the blow-pipe, in a ſilver ſpoon, it becomes red by the yellow cone of the flame, while the blue cone renders it yellow †. On charcoal it is immediately reduced.

‖ *Kirwan.*
§ *Gellert.*
* *Pelletier, Ann. de Chim.* ix. 56.
† *Ribbentrapp, Ann. de Chim.* xxv. 189.

It contains from .60 to .85 of lead, and from .18 to .24 of carbonic acid. It is generally contaminated with carbonat of lime and oxyd of iron.

(K) See *Hauy, Jour. de Min.* Nº XXXI. 502. and *Romé de Liſle,* III. 380.

240 Phoſphat of lead. [†] Kirw. ii. 207.

SPECIES 2. Phoſphat of lead[†].

This ore, which is found in Siberia, Scotland, England, Germany, Carinthia, Brittany, &c. is ſometimes amorphous, and ſometimes cryſtallized. The primitive form of its cryſtals, according to Romé de Liſle, is a dodecahedron, conſiſting of a ſix-ſided rectangular priſm, terminated by ſix ſided pyramids, the ſides of which are iſoſceles triangles (L). Sometimes the pyramids are truncated, and even altogether wanting. The cryſtals of this ore are often acicular.

Its colour is commonly green; ſometimes yellowiſh or browniſh, or greyiſh white. Streak commonly greeniſh white. Powder yellowiſh. External luſtre, waxy, 2 to 3. Somewhat tranſparent, except when its colour is greyiſh white. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.86[*] to 6.27[†]. Inſoluble in water and ſulphuric acid, and nearly inſoluble in nitric acid; ſoluble in hot muriatic acid, with a ſlight efferveſcence[‡]. Before the blow-pipe it eaſily melts on charcoal, and cryſtallizes on cooling: with ſoda the lead is in ſome meaſure reduced.

[*] Briſſon.
[†] Klaproth.
[‡] Fourcroy, Ann. de Chim. ii. 207.

The compoſition of this ore was firſt diſcovered by Gahn.

According to Fourcroy's analyſis, a ſpecimen from Erlenbach in Alſace, conſiſts of

96 phoſphat of lead,
2 phoſphat of iron,
2 water.

100

Or it contains 79 oxyd of lead,
1 oxyd of iron,
18 phoſphoric acid,
2 water.

100[¶]

[¶] Ibid.

241 Arſeniat of lead. [§] Kirw. ii. 209.

SPECIES 3. Arſeniat of lead[§].

This ore, which has hitherto been found only in Andaluſia in Spain, and always in quartz or feldſpar, is in ſmall maſſes. Colour meadow green, often paſſing into wax yellow. Luſtre waxy, 2. Tranſparency 2. Before the blow-pipe it melts, and retains its colour, and does not cryſtallize on cooling. When heated to whiteneſs, the arſenic acid eſcapes, and the lead is reduced[*].

[*] Prouſt, Jour. de Phyſ. xxx. 394.

242 Phoſphat and arſeniat of lead. [†] Kirw. ii. 210.

SPECIES 4. Phoſphat and arſeniat of lead.

Arſenio phoſphat of lead[†].

This ore, which has been found in Auvergne in France, is either in maſſes, or cryſtallized in ſmall ſix-ſided priſms, with curvilineal faces.

Colour yellowiſh green, or ſhews alternate layers of pale and light green. Powder yellowiſh. The cryſtals are ſomewhat tranſparent; but when maſſive, this ore is opaque. Hardneſs 5 to 7. Brittle. Sp. gr. 6.8465[‡]. Soluble in hot muriatic acid, but not in nitric. When heated it decrepitates. Before the blow-pipe melts eaſily, effervesces, emits a white ſmoke, with an arſenical ſmell. Some particles of lead are reduced, a brown fluid remains, which cryſtallizes on cooling like phoſphat of lead.

[‡] Briſſon.

According to Fourcroy, from whom the whole of this deſcription has been taken, it is compoſed of

65 arſeniat of lead,
27 phoſphat of lead,
5 phoſphat of iron,
3 water.

100[*]

[*] Ann. de Chim. ii. 23.

243 Molybdat of lead.

SPECIES 5. Molybdat of lead (M).

This ore, which is found in Carinthia and at Leadhills in Scotland, was firſt mentioned in 1781 by Mr Jacquin (N). It occurs either in maſſes, or cryſtallized in cubic, or rhomboidal, or octohedral plates.

Its colour is yellow. Streak white. Luſtre waxy. Generally ſomewhat tranſparent. Texture foliated. Fracture conchoidal. Hardneſs 5 to 6. Sp. gr. 5.486[†]; when purified from its gangue by nitric acid, 5.706[‡].

Soluble in fixed alkalies and in nitric acid. Communicates a blue colour to hot ſulphuric acid. Soluble in muriatic acid, and decompoſed by it. Before the blow-pipe decrepitates, melts into a yellowiſh grey maſs, and globules of lead are reduced[‖].

[†] Macquart.
[‡] Hatchett.
[‖] Macquart.

Klaproth firſt proved that this ore was molybdat of lead.

A very pure ſpecimen, analyſed by him, contained

64.42 oxyd of lead,
34.25 molybdic acid.

98.67[¶]

[¶] Beiträge, ii. 275.

According to the analyſis of Mr Hatchett, it is compoſed of

58.40 oxyd of lead,
38.00 molybdic acid,
2.10 oxyd of iron,
.28 ſilica.

98.78[*]

[*] Phil. Tranſ. lxxxvi. 323.

Macquart found a ſpecimen to contain

58.74 lead,
4.76 oxygen,
28.00 molybdic acid,
4.50 carbonat of lime,
4.00 ſilica.

100.00[†]

[†] Jour. de Min. N° xvii. 32.

Its gangue is carbonat of lime.

244 Sulphat of lead. [*] Kirw. Min ii. 211.

SPECIES 6. Sulphat of lead[‡].

This ore, which is found in Angleſey and in Andaluſia, is generally cryſtallized. The cryſtals are regular octohedrons[§], and very minute.

Colour white. Luſtre 4. Tranſparency 4. Before the blow-pipe it is immediately reduced.

The compoſition of this ore was firſt aſcertained by Dr Withering.

[§] Hauy, Jour. de Min. N° xxxi. 508.

ORDER IX. ORES OF ZINC.

HITHERTO zinc has not been applied to a great variety of uſes. It enters into the compoſition of braſs; it is uſed in medicine; and Morveau has ſhewn that its

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(L) *Cryſtal.* III. 391. See alſo *Hauy's* remarks on the ſame ſubject in the *Jour. de Min.* N° XXXI, 506.

(M) *Kirw.* II. 212.—*Klaproth, Ann. de Chim.* VIII. 103.—*Hatchett, Phil. Tranſ.* 1796, p. 285.

(N) In his *Miſcellanea Auſtriaca*, Vol. II. p. 139.

Ores of Zinc.

oxyd might be employed with advantage as a white paint.

Ores of zinc are very abundant; they generally accompany lead ores, particularly galena. Calamine, or oxyd of zinc, has never been diſcovered in the primitive mountains.

243
G. I. Sulphurets.
Common ſulphuret of zinc.

GENUS I. SULPHURETS OF ZINC.

SPECIES 1. Common ſulphuret of zinc*.

Blende.

This ore very commonly accompanies ſulphuret of lead. It occurs both in amorphous maſſes and cryſtallized. The primitive form of its cryſtals is a rhomboidal dodecahedron, conſiſting of a ſix-ſided priſm, terminated by three-ſided pyramids. All the faces of the cryſtals are equal rhombs. This dodecahedron may be mechanically divided into four equal rhomboidal parallelopipeds, and each of theſe into ſix tetrahedrons, whoſe faces are equal iſoſceles triangles. The figure of its integrant particles is the tetrahedron, ſimilar to theſe *.

The principal varieties of its cryſtals are the tetrahedron; the octohedron; the octohedron with its edges wanting*; a 24 ſided cryſtal, 12 of whoſe faces are trapezoids, and 12 elongated triangles†; and, laſtly, a 28-ſided figure, which is the laſt variety, augmented by four equilateral triangles†.

Colour yellow, brown, or black. Streak reddiſh, browniſh, or grey. Luſtre commonly metallic. Generally ſomewhat tranſparent. Texture foliated. Hardneſs 6 to 8. Sp. gr. 3.93‡ to 4.1665¶. Before the blow-pipe decrepitates, and gives out white flowers of zinc, but does not melt. Borax does not affect it. When breathed upon, loſes its luſtre, and recovers it very ſlowly‖.

Variety 1. Yellow blende.

Colour commonly ſulphur yellow, often paſſing into olive green or browniſh red. Powder pale yellow. Streak yellowiſh or reddiſh grey, not metallic. Luſtre metallic. Tranſparency 2 to 4. Often phoſphoreſces when ſcraped or rubbed*.

According to Bergman, it is compoſed of

64 zinc,
20 ſulphur,
5 iron,
4 fluor acid,
1 ſilica,
6 water.

100†

Variety 2. Brown blende.

Colour different ſhades of brown. Surface often tarniſhed. Powder browniſh grey. Streak reddiſh or yellowiſh grey, not metallic. Luſtre commonly metallic. Tranſparency 0 to 2.

A ſpecimen of this variety, analyſed by Bergman, contained

44 zinc,
17 ſulphur,
24 ſilica,
5 iron,
5 alumina,
5 water.

100‡

Variety 3. Black blende.

Colour black, or browniſh black; ſurface often tarniſhed blue; tips of the cryſtals often blood red. Powder browniſh black. Streak reddiſh, browniſh, or grey. Luſtre common or metallic. Tranſparency 0 to 1; the red parts 2. Hardneſs 8.

A ſpecimen of this variety, analyſed by Bergman, contained

52 zinc,
26 ſulphur,
4 copper,
8 iron,
6 ſilica,
4 water.

100‡

244
G. II. Oxyds.
White oxyd of zinc.

GENUS II. OXYDS OF ZINC.

SPECIES 1. White oxyd of zinc†.

Calamine.

This ore is either found looſe, or in maſſes, or cryſtallized. The primitive form of its cryſtals appears, from the mechanical diviſion of one of them by Mr Hauy, to be an octohedron compoſed of two four-ſided pyramids, whoſe ſides are equilateral triangles†. But the cryſtals are minute, and their figure not very diſtinct. They are either four or ſix ſided tables with bevelled edges, ſix-ſided priſms, or three-ſided pyramids.

Colour commonly white, grey, or yellow. Luſtre often 0, ſometimes 2 or 1. Opaque. The cryſtals are ſomewhat tranſparent. Hardneſs from 4 to 9, ſometimes in powder. Sp. gr. from 2.565 to 3.674‡. When heated, becomes electric, without friction, like the tourmaline†. Not blackened by ſulphuret of ammonia. Soluble in ſulphuric acid. Before the blow-pipe decrepitates, and does not melt.

This ore conſiſts of oxyd of zinc more or leſs contaminated with iron, ſilica, lime, and other foreign ingredients. In one ſpecimen Bergman found the following ingredients: 84 oxyd of zinc,
3 oxyd of iron,
12 ſilica,
1 alumina.

100 ¶

In another ſpecimen, which gelatinized with acids, like zeolite, Klaproth found 66 oxyd of zinc,
33 ſilica.

99

In another ſpecimen, analyſed by Pelletier, the contents were

32 ſilica,
56 oxyd of zinc.
12 water.

100 *

Mr Kirwan has divided this ſpecies into three varieties.

Variety 1. Friable calamine.

In maſſes which eaſily crumble between the fingers. Luſtre 0. Opaque. Texture earthy. When its colour is white, it is pure oxyd of zinc; when yellow, it is mixed with oxyd of iron. The white often becomes yellow when placed in a red heat, but reſumes its colour on cooling. Common in China, where it is called *woham* or *ore of Tutenago.*

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* *Kirw.* ii. 238.—*Berg.* ii. 329.

* *Hauy, Jour. de Min.* N° xxxiii. 669.

* *Fig.* 40.

† *Fig.* 41.

† See *Hauy, ibid* and *Romé de Liſle,* iii. 65.

‡ *Gellert.*

¶ *Briſſon.*

‖ *Hauy, Jour de Min. ibid.*

* *Bergman,* ii. 345.

† *Ibid.* 347.

‡ *Ibid.* 333.

‡ *Bergman,* ii. 335.

† *Kirw* ii. 253.—*Berg.* ii. 321.

† *Jour. de Min.* N° xxxiii. 596.

‡ *Kirwan.*

† *Hauy, Jour. de Min. ibid.*

¶ *Bergman,* ii. 323.

* *Jour. de Phyſ.* xx. 428.

Variety 2. Compact calamine.

Colour different ſhades of grey; ſometimes yellow or browniſh red. Luſtre 0. Opaque. Texture compact.

Variety 3. Striated calamine.

This variety alone is found cryſtallized; but, like the others, it is alſo often amorphous. Colour white, and alſo various ſhades of grey, yellow, and red. Somewhat tranſparent. Texture ſtriated. Luſtre 2 to 1.

247
G. III. Salts. Sulphat of zinc.

GENUS III. SALTS OF ZINC.

SPECIES 1. Sulphat of zinc.

For a deſcription of this ſalt, we refer to CHEMISTRY, n° 643. *Suppl.*

ORDER X. ORES OF ANTIMONY.

ANTIMONY is much uſed to give hardneſs to thoſe metals which otherwiſe would be too ſoft for certain purpoſes: printers types, for inſtance, are compoſed of lead and antimony. It is uſed alſo in medicine.

Ores of antimony are found abundantly in Germany, Hungary, France, Spain, Britain, Sweden, Norway, &c. They often accompany galena and hæmatites. They are found both in the ſecondary and primitive ſtratified mountains. Their gangue (o) is often quartz and ſulphat of barytes.

248
G. I. Alloys Native antimony.
* *Kirw.* ii. 245.

GENUS I. ALLOYS OF ANTIMONY.

SPECIES 1. Native antimony *.

This mineral, which was firſt diſcovered by Dr Swab, has been found in Sweden and in France, both in maſſes and kidney-ſhaped lumps. Colour white, between that of tin and ſilver. Luſtre metallic. Texture foliated. Hardneſs 6. Sp. gr. above 6. Deflagrates with nitre. Before the blow-pipe melts and evaporates, depoſiting a white oxyd of antimony.

It conſiſts of antimony, alloyed with 3 or 4 *per cent.* of arſenic.

249
G. II. Sulphurets. Grey ore of antimony.
* *Kirw.* ii. 247.

GENUS II. SULPHURETS OF ANTIMONY.

SPECIES 1. Grey ore of antimony *.

This ore, which is the moſt common, and indeed almoſt the only ore of antimony, occurs both maſſive, diſſeminated, and cryſtallized. Its cryſtals are four-ſided priſms, ſomewhat flattened, whoſe ſides are nearly rectangles, terminated by ſhort four-ſided pyramids, whoſe ſides are trapeziums †. Sometimes two of the edges are wanting, which renders the priſm ſix-ſided ‡.

† *Romé de Liſle*, iii. 49
‡ *Ibid.*—See alſo *Hauy, Jour. de Min.* N° xxxii. 606.
¶ *Briſſon.*

Colour grey. Luſtre metallic. Streak grey, metallic, and brighter. Powder black or greyiſh black. Hardneſs 6 to 7. Sp. gr. from 4.1327 to 4.516 ¶. Often ſtains the fingers. Before the blow pipe melts eaſily, burns with a blue flame, and depoſits a white oxyd on the charcoal. When placed in an open veſſel, over a ſlow fire, the ſulphur evaporates, and leaves a grey oxyd of antimony. This oxyd, if fuſed with tartar, is reduced.

This ore, when taken out of the mine, almoſt always contains a large proportion of quartz or other ſtony matter. When pure, it is compoſed of about

74	antimony,
26	ſulphur.
100	

Werner has divided this ſpecies into three varieties.

Variety 1. Compact ſulphuret.

Colour bluiſh grey, ſurface often tarniſhed, and then it is blue or purpliſh. Luſtre 1 to 2. Texture compact. Fracture fine grained, uneven. Powder black, dull, and earthy. Slightly ſtains the fingers.

Variety 2. Foliated ſulphuret.

Colour light ſteel grey. Luſtre 3 to 4. Texture foliated. Powder as that of the laſt variety.

Variety 3. Striated ſulphuret.

Colour dark ſteel grey, and light bluiſh grey; ſurface often tarniſhed, and then it is dark blue or purpliſh. Luſtre 3 to 2. Texture ſtriated. Powder greyiſh black. This variety alone has been hitherto found cryſtallized.

250.
Plumoſe antimonial ore.
† *Kirw.* ii. 250.

SPECIES 2. Plumoſe antimonial ore †.

Sulphurets of antimony and arſenic.

This ſpecies, which is ſometimes found mixed with the cryſtals of ſulphurated antimony, is in the form of brittle, capillary, or lanuginous cryſtals, often ſo ſmall that they cannot be diſtinctly ſeen without a microſcope.

Colour ſteel or bluiſh grey, often tarniſhed, and then brown or greyiſh black. Luſtre 1, ſemimetallic. Before the blow-pipe emits a ſmoke, which depoſits a whitiſh and yellowiſh powder on the charcoal: it then melts into a black ſlag.

It is ſuppoſed to conſiſt of ſulphur, antimony, arſenic, and ſome ſilver.

251
Red antimonial ore.
† *Kirw.* ii. 250.

SPECIES 3. Red antimonial ore †.

Hydroſulphuret of antimony.

This ſpecies is generally found in cavities of ſulphurated antimonial ore. It is cryſtallized in delicate needles, often diverging from a common centre.

Colour red. Luſtre 2, ſilky. Sp. gr. 4.7. Before the blow-pipe melts eaſily, and evaporates with a ſulphureous ſmell.

This ore has not been analyſed. Mineralogiſts have ſuppoſed it to be a natural kermes. If ſo, we may conclude, from the experiments of Berthollet *, that it is a hydroſulphuret of antimony, and conſequently compoſed of oxyd of antimony, ſulphur, and ſulphurated hydrogen gas.

* *Ann. de Chim.* xxv. 259.

252
G. III. Oxyds of antimony.

GENUS III. OXYDS OF ANTIMONY.

There is a ſubſtance found incumbent on ſulphuret of antimony, of a yellow colour, and an earthy appearance, which has been ſuppoſed an oxyd of antimony, and denominated antimonial ochre. But hitherto it has not been analyſed.

(o) The word *gang* is uſed by German mineralogiſts to denote a metallic vein. Now, it is not often that theſe veins conſiſt entirely of *ore;* in general, they contain ſtony matter beſides. For inſtance, in the copper mine at Airthry, near Stirling, the copper ore is merely a narrow ſtripe in the middle of the vein, and the reſt of it is filled up with ſulphat of barytes. We uſe the word *gangue* (as the French do), to denote, not the *metallic* vein, but the *ſtony* matter which accompanies the ore in the vein. The gangue of the copper ore at Airthry is ſulphat of barytes.

253
G. IV. Salts
Muriat of antimony.
* Kirw. ii. 251.

GENUS IV. SALTS OF ANTIMONY.

SPECIES 1. Muriat of antimony*.

This ore, which has been found in Bohemia, is ſometimes in quadrangular tables; ſometimes in acicular cryſtals grouped like zeolites; and ſometimes in priſms.

† *Hauy, Jour. de Min.* N° xxxii. 609.

Colour pale yellowiſh or greyiſh white. Luſtre 3 to 1, nearly metallic. Tranſparency 2. Texture foliated. Melts eaſily by the flame of a candle, and emits a white vapour.†. Before the blow-pipe decrepitates; when powdered, and juſt ready to melt, it evaporates, and leaves a white powder around. Between two pieces of coal it is reducible to a metallic ſtate.

* *Pott, Obſerv. Chym.* 134—*Geoffroy, Mem. Par.* 1753, p. 296.

ORDER XI. ORES OF BISMUTH*.

BISMUTH is employed in the manufacture of pewter, of printers types, in ſoldering; and perhaps alſo its property of rendering other metals more fuſible, might make it uſeful in anatomical injections. The quantity conſumed in commerce is not great.

It has been found only in the primitive mountains, and is by no means common. When unaccompanied by any other metal, it does not form veins, but kidney-form maſſes. It often accompanies cobalt. Its gangue is commonly quartz. Its ores are not very abundant. They have been found chiefly in Sweden, Norway, Tranſylvania, Germany, France, and England

254
G. I. Alloys. Native biſmuth.
* *Kirw.* ii. 264.

GENUS I. ALLOYS OF BISMUTH.

SPECIES 1. Native biſmuth*.

This mineral, which is found at Schneeberg, Johangeorgenſtadt, &c. in Germany, has commonly the form of ſmall plates lying above one another. Sometimes it is cryſtallized in four-ſided tables, or indiſtinct cubes.

† *Briſſon.*
‡ *Kirwan.*

Colour white with a ſhade of red; ſurface often tarniſhed red, yellow, or purple. Luſtre metallic, 3 to 2. Opaque. Texture foliated or ſtriated. Hardneſs 6. Sp. gr. 9.022† to 9.57‡. Exceedingly fuſible. Before the blow-pipe gives a ſilvery white bead, and at laſt evaporates in a yellowiſh white ſmoke, which is depoſited on the charcoal.

It is generally accompanied by cobalt, and ſometimes contains arſenic.

255
G. II. Sulphurets. Common ſulphuret of biſmuth.
* *Kirw.* ii. 266.—*Sage, Mem. Par.* 1782, 307.

GENUS II. SULPHURETS OF BISMUTH.

SPECIES 1. Common ſulphuret of biſmuth*.

This ore, which is found in Sweden, Saxony, and Bohemia, occurs ſometimes in amorphous maſſes, and ſometimes in needleform cryſtals.

† *Kirwan*
‡ *Briſſon.*

Colour commonly bluiſh grey, ſometimes white; ſurface often tarniſhed yellow, red, and purple. Powder black and ſhining. Luſtre metallic, 2 to 3. Streak obſcurely metallic. Texture foliated. Hardneſs 5. Brittle. Sp gr. 6.131† to 6.4672‡. When held to the flame of a candle, it melts with a blue flame and ſulphureous ſmell. Before the blow-pipe emits a reddiſh yellow ſmoke, which adheres to the charcoal. This powder becomes white when it cools, and reſumes its former colour when the flame is directed upon it*.

* *Gillot, Jour. de Min.* N° xxxii. 585.

This ore, according to Sage, contains 60 biſmuth, And, according to La Perouſe, it holds 36 ſulphur.

A ſpecimen, analyſed by Klaproth, contained
95 biſmuth,
5 ſulphur.

100†

† *Beiträge,* i. 256.

It is commonly accompanied by quartz, aſbeſtos, or ſparry iron ore.

256
G. III. Oxyds. Yellow oxyd of biſmuth.
‡ *Kirw.* ii. 263.

GENUS III. OXYDS OF BISMUTH.

SPECIES 1. Yellow oxyd of biſmuth‡.

Biſmuth ochre.

This ore generally accompanies the two ſpecies already deſcribed. It is found in two ſtates; either of an earthy conſiſtence, or cryſtallized in cubes or quadrangular plates.

Colour uſually greeniſh yellow, ſometimes grey. Soluble in nitrous acid without effervеſcence, and may in a great meaſure be precipitated by the effuſion of water.

ORDER XII. ORES OF ARSENIC.

ARSENIC is uſed as an alloy for ſeveral other metals, eſpecially copper. It is ſometimes employed to facilitate the fuſion of glaſs, or to render it opaque, in order to form an enamel. Preparations of arſenic are employed as paints; and, like moſt other violent poiſons, it has been introduced into medicine.

This metal is ſcattered in great abundance over the mineral kingdom, accompanying almoſt every other metal, and forming alſo ſometimes peculiar veins of its own. Of courſe it occurs in almoſt every ſpecies of mountain, and is accompanied by a variety of gangues.

257
G. I. Alloys. Native arſenic.
† *Kirw.* ii. 255.

GENUS I. ALLOYS OF ARSENIC.

SPECIES 1. Native arſenic†.

This mineral is found in different parts of Germany. It occurs generally in maſſes of various ſhapes, kidney-form, botryoidal, &c.

† *Kirwan.*
‡ *Briſſon.*

Colour that of ſteel. Its ſurface quickly becomes tarniſhed by expoſure to the air. Luſtre metallic (when freſh), 3 to 2. Streak bluiſh grey, metallic, and bright. Powder dull and black. Texture compact. Hardneſs 7 to 8. Brittle. Sp. gr. 5.67† to 5.7249‡. Gives an arſenical ſmell when ſtruck. Before the blow-pipe emits a white ſmoke, diffuſes a garlic ſmell, burns with a blue flame, gradually evaporates, depoſiting a white powder.

§ *De Born, Cat. of M. Raab,* ii. 194.

It is always alloyed with ſome iron §, and often contains ſilver, and ſometimes gold.

258
G. II. Sulphurets. Orpiment.

GENUS II. SULPHURETS OF ARSENIC.

SPECIES 1. Orpiment (p).

Auripigmentum.

This ore, which is found in Hungary, Wallachia, Georgia, and Turkey in Aſia, is either maſſive or cryſtallized. The cryſtals are confuſed, and their figure cannot be eaſily determined; ſome of them appear octohedrons, and others minute four ſided priſms.

* *Kirwan.*
‡ *Gellert.*

Its colour is yellow. Streak orange yellow. Luſtre waxy, 2 to 3. Tranſparency from 0 to 2. Texture foliated. Hardneſs 4 to 8. Sp. gr. from 3.048* to 3.521‡. Effervеſces with hot nitric acid. Burns with

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(p) *Kirw.* II. 260.—*Alberti de Auripigmento.*—*Scopoli in Anno 5to Hiſt. Naturali,* p. 59,—*Berg.* II. 297.

Ore of Arſenic.

a bluiſh white flame. Before the blow-pipe melts, ſmokes, and evaporates, leaving only a little earth and ſome traces of iron.

Compoſed of
80 ſulphur,
20 arſenic.
———
100

259 Realgar.

SPECIES 2. Realgar*.

This mineral is found in Sicily, about Mount Veſuvius, in Hungary, Tranſylvania, and various parts of Germany. It is either maſſive or cryſtallized. The primitive form of the cryſtals is, according to Romé de Liſle, a four-ſided rhomboidal priſm, terminated by four-ſided pyramids, the ſides of which are rhombs†. It commonly appears in 4, 6, 8, 10, or 12 ſided priſms, terminated by four-ſided ſummits‡.

Colour red. Streak yellowiſh red. Powder ſcarlet. Luſtre 3 to 2. Tranſparency from 2 to 3; ſometimes 0. Hardneſs 5 to 6. Sp. gr. 3.3384§. It is an electric *per ſe*, and becomes negatively electric by friction‖. Nitric acid deprives it of its colour. Before the blow pipe it melts eaſily, burns with a blue flame and garlic ſmell, and ſoon evaporates.

Compoſed of
20 ſulphur,
80 arſenic.
———
100

260 G. III. Oxyds. White oxyd of arſenic.

Genus III. OXYDS OF ARSENIC.

SPECIES 1. White oxyd of arſenic*.

Native calx of arſenic.

This ore is found in various parts of Germany, Hungary, &c. either in powder, or maſſive, or cryſtallized in priſmatic needles.

Colour white or grey, often with a tint of red, yellow, green, or black. Luſtre common, 1 to 2. Tranſparency 1 to 0; when cryſtallized, 2. Texture earthy. Hardneſs 6. Brittle. Sp. gr. 3.7†. Soluble in hot diluted nitric acid without efferveſcence. Soluble at 60° Fahrenheit in 80 times its weight of water. Before the blow-pipe ſublimes, but does not inflame. Tinges borax yellow.

Order XIII. COBALT ORES.

Cobalt is employed to tinge glaſs of a blue colour, and is uſeful in painting upon porcelain.

Cobalt ores are found almoſt excluſively in the ſtratified mountains, except one ſpecies, ſulphuret of cobalt, which affects the primitive mountains. They are not very abundant; and for that reaſon cobalt is more valuable than many of the other metals which have been already treated of. They are commonly accompanied by nickel, biſmuth, or iron. They are moſt abundant in Germany, Sweden, Norway, and Hungary; they have been found alſo in Britain and France, but not in any great quantity.

261 I. Alloys. obalt alloyed with ſenic.

Genus I. ALLOYS OF COBALT.

SPECIES 1. Cobalt alloyed with arſenic†.

Dull grey cobalt ore.

This ore, which occurs in different parts of Germany, is either amorphous or cryſtallized. The forms of its cryſtals are the cube; ſometimes the cube with its angles, or edges, or both wanting; and the octohedron‡.

Metallic Ores.

Its colour, when freſh broken, is whitiſh or bluiſh grey, ſometimes with a ſhade of red; when expoſed to the air it ſoon becomes tarniſhed. Streak bluiſh grey and metallic. Luſtre ſcarcely metallic, 0 to 1. Texture compact. Hardneſs 10. Difficultly frangible. Sp. gr. when amorphous, 5.309 to 5.571§; when cryſtallized 7.7207† When ſtruck it gives out an arſenical ſmell. Before the blow-pipe it gives out an arſenical vapour, becomes magnetic, and melts eaſily, unleſs it contains a great quantity of iron. Tinges borax dark blue, and a ſmall metallic bead is obtained.

A ſpecimen of this ore from Cornwall, examined by Mr Klaproth, contained
20 cobalt,
24 iron,
33 arſenic,
———
77

with ſome biſmuth and ſtony matter*.

Another ſpecimen from Tunaberg, according to the analyſis of the ſame chemiſt, contained
55.5 arſenic,
44.0 cobalt,
.5 ſulphur.
———
100†

262 G. II. Sulphurets. White cobalt ore.

Genus II. SULPHURETS OF COBALT.

SPECIES 1. White cobalt ore‡.

Sulphuret of cobalt, arſenic, and iron.

The deſcriptions which different mineralogiſts have given of this ore are ſo various, that it is impoſſible not to ſuppoſe that diſtinct ſubſtances have been confounded together.

It occurs either in maſſes, or cryſtallized in cubes, dodecahedrons, octohedrons, and icoſahedrons.

Colour tin white, ſometimes tarniſhed reddiſh or yellowiſh. Powder ſteel grey. Luſtre partly metallic, and from 2 to 4; partly 0 or 1. Texture foliated. Hardneſs 8 to 9. Sp. gr. from 6.284† to 6.4509‡. Before the blow-pipe generally gives out an arſenical vapour, and does not melt.

The analyſes that have been given of this ore are very various. Sometimes it has been found to contain no arſenic nor iron, and ſometimes to contain both. A ſpecimen from Tunaberg in Sweden, which ought to belong to this ſpecies, was analyſed by Taſſaert, and found to conſiſt of
49 arſenic,
36.6 cobalt,
5.6 iron,
6.5 ſulphur.
———
97.8†

Klaproth found a ſpecimen of the ſame ore to contain
55.5 arſenic,
44.0 cobalt,
0.5 ſulphur.
———
100.0‡

263 G. III. Oxyds. Black cobalt ore or ochre.

Genus III. OXYDS OF COBALT.

SPECIES 1. Black cobalt ore or ochre§.

This ore, which occurs in different parts of Germany, is either in the form of a powder, or indurated.

Colour black, often with a ſhade of blue, grey, brown, or green. Luſtre 0 to 1. Streak brighter. Hardneſs (of the indurated) from 4 to 8. Sp. gr. 3 to 4. Soluble in muriatic acid. Tinges borax blue.

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* Kirw. ii. 261.—Berg. ii. 297.

† Cryſtall. iii. 34.

‡ Ibid.

§ Briſſon.

‖ Hauy, Jour. de Min. No xxiii. 612.

* Kirw. ii 258.—Berg. ii 285.

† Kirwan.

† Kirw. ii. 0.

‡ Romé de ſle, iii. 3.

§ Kirw. ii. 270.

† Hauy, Jour. de Min. No xxiii. 588.

* Klaproth's Cornwall, p. 62.

† Beiträge, ii. 307.

‡ Kirw. ii. 273.—Sage, Jour. de Phyſ. xxxix. 53.

† Kirwan.

‡ Hauy.

† Ann. de Chim. xxviii. 100.

‡ Beiträge, ii 307.

§ Kirw. ii. 275.

SPECIES 2. Brown cobalt ore*.

264 Brown cobalt ore. * Kirw. ii. 276.

Colour greyiſh or dark leather brown. Streak brighter, unctuous. Communicates a pale blue tinge in fuſion.

SPECIES 3. Yellow cobalt ore †.

265 Yellow cobalt ore. † Ibid.

Colour yellow. Dull and earthy. Hardneſs 4 to 5. Texture earthy. Streak brighter, unctuous. Gives a weak blue tinge.

GENUS IV. SALTS OF COBALT.

SPECIES 1. Arſeniat of cobalt ‡.

Red cobalt ore.

266 G. IV. Salts. Arſeniat of cobalt. ‡ Id. 278.

This ſpecies, like moſt other ores of cobalt, has neither been accurately deſcribed nor analyſed.

It is found in maſſes of various ſhapes, and cryſtallized in quadrangular tables or acicular priſms.

Colour red. Luſtre from 2 to 3, ſometimes 0. Tranſparency 0 to 2. Hardneſs 5 to 7. Brittle. Before the blow-pipe becomes blackiſh grey. Diffuſes a weak arſenical ſmell. Tinges borax blue.

ORDER XIV. ORES OF NICKEL.

HITHERTO nickel has been found in too ſmall quantities to be applied to any uſe; of courſe there are, properly ſpeaking, no mines of nickel. It occurs only (as far as is yet known) in the ſecondary mountains, and it commonly accompanies cobalt. It has been found in different parts of Germany, in Sweden, Siberia, Spain, France, and Britain.

GENUS I. SULPHURETS OF NICKEL.

SPECIES 1. Sulphuret of nickel with arſenic and iron.

*Kupfer nickel**.

267 G. I. Sulphurets. Sulphuret of nickel with arſenic and iron. * Ibid. 286.

This, which is the moſt common ore of nickel, occurs either maſſive or diſſeminated, but never cryſtallized.

Colour often that of copper, ſometimes yellowiſh white or grey. Recent fracture often ſilver white. Luſtre metallic, 2 to 3. Texture compact. Hardneſs 8. Sp. gr. 6.6086 to 6.6481 ‡. Soluble in nitric and nitro-muriatic acids. Solution green. Before the blow-pipe exhales an arſenical ſmoke, and melts into a bead which darkens by expoſure to the air.

‡ Briſſon.

It is compoſed of various proportions of nickel, arſenic, iron, cobalt, ſulphur; often contains biſmuth, and ſometimes ſilver and copper.

GENUS II. OXYDS OF NICKEL.

SPECIES 1. Nickel ochre *.

268 G. II. Oxyds. Nickel ochre. * Kirw. ii. 284.

This mineral occurs either in the form of a powder, or indurated, and then is either amorphous, or cryſtallized in acicular form cryſtals. The powder is generally found on the ſurface of other nickel ores.

Colour different ſhades of green. Luſtre 1 to 0. Texture earthy. Sp. gr. conſiderable. Slowly diſſolves in acids: ſolution green. Before the blow-pipe does not melt; but gives a yellowiſh or reddiſh brown tinge to borax.

This ore often contains ſulphat of nickel, which is ſoluble in water. The ſolution, when evaporated, gives oblong rhomboidal cryſtals, from which alkalies precipitate a greyiſh green oxyd. This oxyd is ſoluble by acids and by ammonia. The acid ſolution is green; the alkaline blue.

GENUS III. SALTS OF NICKEL.

SPECIES 1. Arſeniat of nickel †.

269 G. III. Salts. Arſeniat of nickel. † Kirw. ii. 285.

This ore, which was lately diſcovered at Regendorff by Mr Gmelin, is found in ſhapeleſs maſſes, and is often mixed with plates of ſulphat of barytes.

Colour pale grey, here and there mixed with pale green. Streak white. Luſtre 0. Texture compact. Hardneſs 7. Difficultly frangible. Sp. gr. conſiderable. Adheres ſlightly to the tongue, and gives an earthy ſmell when breathed on. Soluble in hot nitric and muriatic acids: ſolution green.

Contains ſome cobalt and alumina.

ORDER XV. ORES OF MANGANESE (q).

HITHERTO manganeſe, in its metallic ſtate, has ſcarcely been put to any uſe; but under the form of an oxyd it has become of great importance. The oxyd of manganeſe has the property of rendering colourleſs a variety of bodies which injure the tranſparency of glaſs; and it has been long uſed in glaſs manufactories for this purpoſe under the name of *glaſs ſoap*. By means of the ſame oxyd, oxy-muriatic acid is prepared, which has rendered manganeſe of great importance in bleaching. Not to mention the utility of manganeſe to the chemiſt, the property which it has of facilitating the oxydation of other metals, and of rendering iron more fuſible—will probably make it, in no very remote period, of very conſiderable importance in numerous manufactories.

Ores of manganeſe occur often in ſtrata, both in the primitive and ſecondary mountains; ſcarcely ever, however, we believe, in thoſe mountains which are conſidered as the moſt ancient of all. They are very common, having been found abundantly in Germany, France, Spain, Britain, Sweden, Norway, Siberia, and other countries.

GENUS I. OXYDS OF MANGANESE.

270 G. I. Oxyds.

Hitherto manganeſe has only been found in the ſtate of oxyd. La Perouſe, indeed, ſuſpected that he had found it in a metallic ſtate: but probably there was ſome miſtake or other in his obſervations.

SPECIES 1. Oxyd of manganeſe combined with barytes.

271 Oxyd of manganeſe combined with barytes.

This ſpecies, which exiſts in great abundance in Romaneche near the river Soane in France, is found maſſive, forming a ſtratum in ſome places more than 12 feet thick.

Colour greyiſh black or browniſh black, of great intenſity. Luſtre, external, 0; internal, metallic, 1. Soon tarniſhes by expoſure to the air, and then becomes intenſely black. Texture granular. Fracture uneven; ſometimes conchoidal. Often porous. Hardneſs 11. Difficultly frangible. Sp. gr. from 3.950 to 4.10. Abſorbs water. When taken out of water after a minute's immerſion, it has a ſtrong argillaceous ſmell. Conducts electricity nearly as well as if it were in a metallic ſtate ‡. Infuſible by the blow-pipe. Tinges ſoda red; the colour diſappears before the blue cone of flame, and is reproduced by the action of the yellow flame.

(q) *Pott. Miſcelan. Beroleas*, VI. 40.—*Margraff, Mem. Berlin*, 1773, p. 3.—*La Perouſe, Jour. de Phyſ.* XVI. 156. and XV. 67. and XXVIII. 68.—*Sage, Mem. Par.* 1785, 235.

From the analyſis of Vauquelin, it appears that it is compoſed of

50.0	white oxyd of manganeſe,
33.7	oxygen,
14.7	barytes,
1.2	ſilica,
.4	charcoal.
100.0 ¶	

¶ Dolomieu, Jour. de Min. Nº xix. 42.

SPECIES 2. Grey ore of manganeſe *.

272 Grey ore of manganeſe. This ore occurs both maſſive and diſſeminated; it is alſo ſometimes cryſtallized in ſlender four-ſided priſms or needles.

Colour uſually duſky ſteel grey; ſometimes whitiſh grey, or reddiſh grey. Streak and powder black. External luſtre 3 to 2; internal metallic, 2 to 1. Texture ſtriated or foliated. Hardneſs 4 to 5. Brittle. Sp. gr. from 4.073 † to 4.8165 ‡. Before the blow-pipe darkens: tinges borax reddiſh brown.

A ſpecimen of oxyd of manganeſe from the mountains of Voſges, which probably belonged to this ſpecies, and which was analyſed by Vauquelin, was compoſed of

82	oxyd of manganeſe,
7	carbonat of lime,
6	ſilica,
5	water.
100 §	

Sometimes it contains a little barytes and iron.

* Kirwan, ii. 291.

† Vauquelin

‡ Briſſon.

§ Jour. de Min. Nº xvii 13.

SPECIES 3. Black or brown ore of manganeſe *

273 Black or brown ore of manganeſe. This ore is found ſometimes in the ſtate of powder, and ſometimes indurated in amorphous maſſes of various figures. Colour either black, ſometimes with a ſhade of blue or brown; or reddiſh brown. Streak of the harder ſorts metallic; of the others, black. Luſtre 0 to 1; internal (when it is indurated), metallic. Texture compact. Hardneſs 5 to 7. Sp. gr. 3.7076 to 3.9039; that of the powdery ſometimes only 2. Before the blow-pipe it exhibits the ſame phenomena as the laſt ſpecies.

A ſpecimen of this ore, analyſed by Weſtrum, contained

45.00	manganeſe,
14.00	oxyd of iron,
11.00	ſilica,
7.25	alumina,
2.00	lime,
1.50	oxyd of copper,
18.00	air and water.
98.75	

* Kirwan, ii. 292.—Wedgewood, Phil. Tranſ. lxxiii. 284

GENUS II. SALTS OF MANGANESE.

SPECIES 1. Carbonat of manganeſe †.

White ore of manganeſe.

274 G. II. Salts. Carbonat of manganeſe. This ſpecies occurs in Sweden, Norway, and Tranſylvania. It is either in the form of looſe ſcales, or maſſive, or cryſtallized in needles.

Colour white, or reddiſh white. Texture either radiated or ſcaly. Luſtre of the ſcaly 2. Transparency 1 to 2. Hardneſs of the maſſive 6 to 9. Sp. gr. 2.794. Effervesces with mineral acids. Heated to redneſs, blackens. Tinges borax violet.

† Kirwan, ii. 297.

SPECIES 2. Red ore of manganeſe †.

Carbonat of manganeſe and iron.

275 Red ore of manganeſe. This ſpecies has been found in Piedmont and in the Pyrenees. It is ſometimes in powder, ſometimes maſſive, ſometimes cryſtallized in rhomboidal priſms or needles.

Colour pale roſy red, mixed with white. Powder nearly white. Luſtre 0. Tranſparency 1. Hardneſs 8. Sp. gr. 3.233. Effervesces with nitric and muriatic acids. When heated to redneſs becomes reddiſh brown. Tinges borax red.

A ſpecimen, analyſed by Ruprecht, contained

55	ſilica,
35	oxyd of manganeſe,
7	oxyd of iron,
1.5	alumina.
98.5 §	

† Kirwan, ii. 297 — Napion, Mem. Turin, iv. 303.

§ Jour. de Phyſ. xxxix. 22.

ORDER XVI. ORES OF TUNGSTEN.

As no eaſy method has hitherto been diſcovered of reducing tungſten to a metallic ſtate, we need not be ſurpriſed that it has been applied to no uſe. Ores of tungſten are by no means common. They have hitherto been found only in the primitive mountains. Their gangue is commonly quartz. They very often accompany tin ores.

GENUS I. OXYDS OF TUNGSTEN.

SPECIES 1. Wolfram (a).

Oxyds of tungſten, iron, and *manganeſe—Tungſtat of iron* and *manganeſe.*

276 G. I. Oxyds. Wolfram. This ſpecies is found in different parts of Germany, in Sweden, Britain, France, and Spain; and is almoſt conſtantly accompanied by ores of tin. It occurs both maſſive and cryſtallized. The primitive form of its cryſtals, according to the obſervations of Mr Haüy, is a rectangular parallelopiped ‡, whoſe length is 8.66, whoſe breadth is 5, and thickneſs 4.33 *. It is not common, however, to find cryſtals of this perfect form; in many caſes, the angles, and ſometimes the edges, of the cryſtal are wanting ‡; owing, as Mr Haüy has ſhewn, to the ſuperpoſition of plates, whoſe edges or angles decreaſe according to a certain law †.

Colour brown or browniſh black. Streak reddiſh brown. Powder ſtains paper with the ſame colour. Luſtre external, 2; internal, 2 to 3; nearly metallic. Texture foliated. Eaſily ſeparated into plates by percuſſion. Hardneſs 6 to 8. Sp. gr. from 7.006 * to 7.333 †. Moderately electric by communication. Not magnetic. Infuſible by the blow-pipe. Forms with borax a greeniſh globule, and with microcoſmic ſalt a tranſparent globule of a deep red ¶.

The ſpecimen of this ore examined by Meſſrs d'Elhuyarts, was compoſed of

65	oxyd of tungſten,
22	oxyd of manganeſe,
13	oxyd of iron.
100	

‡ Fig. 42.

* Jour. de Min. Nº xix. 8.

‡ Fig. 43.

† Jour. de Min. Nº xix. 8.

* Kirwan.

† Haüy.

¶ Vauquelin, Jour. de Min. Nº xix. 11.

(a) *Kirw.* II. 316.—*De Luyart, Mem. Thoulouſe,* II. 141.—*Gmelin, Crell's Jour.* English tranſ. III. 127, 205, and 293.—*La Perouſe, Jour. de Min.* Nº IV. p. 23.

Another ſpecimen from Pays le Mines in France, analyſed by Vauquelin and Hecht, contained

67.00 oxyd of tungſten,
18.00 black oxyd of iron,
6.25 black oxyd of mangane{ſe},
1.50 ſilica,
7.25 oxyd of the iron and mangane{ſe}.

100.00 §

§ *Vauquelin, Jour. de Min* N° xix. 11.

Genus II. salts of tungsten.

species 1. Tungſtat of lime (s).

Tungſten.

277 G. II. Salts. Tungſtat of lime.

This ore, which is now exceedingly ſcarce, has hitherto been found only in Sweden and Germany. It is either maſſive or cryſtallized; and, according to Hauy, the primitive form of its cryſtals is the octohedron †.

† *Jour. de Min.* N° xxxiii. 657.

Colour yellowiſh white or grey. Luſtre 3 to 2. Tranſparency 2 to 3. Texture foliated. Hardneſs 6 to 9. Sp. gr, 5.8 to 60665. Becomes yellow when digeſted with nitric or muriatic acids. Infuſible by the blow-pipe. With borax forms a colourleſs glaſs, unleſs the borax exceed, and then it is brown. With microcoſmic ſalt it forms a blue glaſs, which loſes its colour by the yellow flame, but recovers it in the blue flame ‡.

‡ *Scheele* and *Bergman.*

It is compoſed of about 70 oxyd of tungſten,
30 lime,

100

with a little ſilica and iron §.

§ *Scheele.*

species 2. Brown tungſtat.

278 Brown tungſtat.

This ore is found in Cornwal, and is either maſſive or compoſed of ſmall cryſtalline grains.

Colour grey, variegated with yellow and brown. Luſtre 2, waxy. Hardneſs 6 to 7. Sp. gr. 5.57. Its powder becomes yellow when digeſted in aqua regia.

According to Klaproth, it is compoſed of

88 oxyd of tungſten,
11.5 lime.

99.5

Order XVII. ORES OF MOLYBDENUM.

If ever molybdenum be found in abundance, it will probably be uſeful in dyeing and painting. At preſent it is very ſcarce, having only been found in Sweden, Germany, Carniola, and among the Alpes. Like tin and tungſten, it affects the primitive mountains.

Genus I. sulphuret of molybdenum.

species 1. Common ſulphuret (t).

Molybdena.

279 G. I. Sulphuret. Common ſulphuret.

This ore, which is the only ſpecies of molybdenum ore at preſent known, is found commonly maſſive; ſometimes, however, it is cryſtallized in hexahedral tables.

Colour light lead grey; ſometimes with a ſhade of red. Streak bluiſh grey, metallic. Powder bluiſh. Luſtre metallic, 3 to 2. Texture foliated. Lamellæ ſlightly flexible. Hardneſs 4. Sp. gr. 4.569 * to 4.7385 †. Feels greaſy; ſtains the fingers. Marks bluiſh black. A piece of reſin rubbed with this mineral becomes poſitively electric ‡. Inſoluble in ſulphuric and muriatic acids; but in a boiling heat colours them green. Effervesces with warm nitric acid, leaving a grey oxyd undiſſolved. Before the blow-pipe, on a ſilver ſpoon, emits a white ſmoke, which condenſes into a white powder, which becomes blue in the internal, and loſes its colour in the external, flame. Scarcely affected by borax or microcoſmic ſalt. Effervesces with ſoda, and gives it a reddiſh pearl colour.

* *Karſten.*
† *Briſſon.*

‡ *Hauy, Jour. de Min.* N° xix. 70.

Compoſed of about 60 molybdenum,
40 ſulphur.

100 *

* *Klaproth.*

Order XVIII. ORES OF URANIUM.

Uranium has hitherto been found only in Germany, and has not been applied to any uſe. The only two mines where it has occurred are in the primitive mountains.

Genus I. oxyds of uranium.

species 1. Sulphuret of uranium †.

Pechblende.

280 G. I. Oxyds. Sulphuret of uranium.

† *Kirwan,* ii. 305.

This ore, which has been found at Johanngeorgenſtadt in Saxony, and Joachimſthal in Bohemia, is either maſſive or ſtratified with other minerals.

Colour black or browniſh black; ſometimes with a ſhade of grey or blue. Streak darker. Powder opaque and black. Luſtre ſemimetallic, from 3 to 1. Fracture conchoidal. Hardneſs 7 to 8. Very brittle. Sp. gr. from 6.3785 ‡ to 7.5, and even higher §. Imperfectly ſoluble in ſulphuric and muriatic acids; perfectly in nitric acid and aqua regia. Solution wine yellow. Infuſible with alkalies in a crucible: infuſible by the blow-pipe *per ſe*. With borax and ſoda forms a grey opaque ſlag; with microcoſmic ſalt, a green glaſs.

‡ *Morveau, Jour. de Min.* N° xxxii 610.
§ *Klaproth, Beiträge,* ii. 197.

Compoſed of oxyd of uranium and ſulphur, and mixed with iron and ſilica, and ſometimes lead.

A ſpecimen of this ore from Joachimſthal, analyſed lately by Klaproth, contained

86.5 uranium,
6.0 ſulphuret of lead,
5.0 ſilica,
2.5 oxyd of iron,

100.0 *

* *Beiträge,* ii. 221.

species 2. Yellow oxyd of uranium ‡.

Uranitic ochre.

281 Yellow oxyd of uranium.

‡ *Kirwan,* ii. 303.

This ore is generally found on the ſurface of the laſt ſpecies at Johanngeorgenſtadt, and is either maſſive or in powder.

Colour yellow, red, or brown. Streak of the yellow ſorts yellow; of the red, orange yellow. Luſtre 0. Slightly ſtains the fingers. Feels meagre. Texture earthy. Hardneſs 3 to 4. Sp. gr. 3.2438 ‖. Infuſible by the blow-pipe; but in a ſtrong heat becomes browniſh grey.

‖ *Hauy, Jour. de Min. ibid.*

Compoſed of oxyd of uranium and oxyd of iron.

Genus

(s) *Kirw.* II. 314.—*Scheele's Works* (French tranſlation), II. 81.—*Bergman, ibid.* p. 94.—*Crell, Chem. Annalen.* 1784. 2 *Band* 195.

(t) *Kirw.* II. 322.—*Scheele's Works* (French tranſlation), I. 236.—*Pelletier, Jour. de Phyſ.* XXVII. 434.—*Ilſemann, ibid.* XXXIII. 292.—*Sage. ibid.* 389.—*Klaproth* and *Modeer, Ann. de Chim.* III. 120.

Genus II. salts of uranium.

species 1. Carbonat of uranium ¶.

282
G. II. Salts
Carbonat of uranium.

This ſubſtance is alſo found at Johanngeorgenſtadt, and near Eibenſtock and Rheinbreidenbach §. It is ſometimes amorphous, but more commonly cryſtallized. Its cryſtals are ſquare plates, octohedrons, and ſix ſided priſms.

¶ Kirwan, ii. 304.
§ Gmelin.

Colour green; ſometimes nearly white; ſometimes, though rarely, yellow. Streak greeniſh white. Luſtre 3 to 2; internal, 2; ſometimes pearly; ſometimes nearly metallic. Tranſparency 2 to 3. Texture foliated. Hardneſs 5 to 6. Brittle. Soluble in nitric acid without effervеſcence. Infuſible by alkalies.

Compoſed of carbonat of uranium, with ſome oxyd of copper. When its colour is yellow it contains no copper.

Order XIX. ORES OF TITANIUM.

Titanium has been known for ſo ſhort a time, and its properties are yet ſo imperfectly aſcertained, that many of its uſes muſt remain to be diſcovered. Its oxyd, as we learn from Mr Darcet, has been employed in painting on porcelain *. Hitherto it has been found only in the primitive mountains, the Crapacks †, the Alpes (v), and the Pyrenees ‡. It has been found alſo in Brittany ‖ and in Cornwal.

* Jour. de Min. N° xv. 27.
† Ibid, N° xii. 51.
‡ Jour. de Min. N° xxxii. 614.
‖ Ibid.

Genus I. oxyds of titanium.

species 1. Red oxyd of Titanium.

Red ſhorl—Sagenite.

283
G. I. Oxyds.
Red oxyd of titanium.

This ore has been found in Hungary, the Pyrenees, the Alpes, and in Brittany in France. It is generally cryſtallized. The primitive form of its cryſtals, according to the obſervations of Mr Hauy, is a rectangular priſm, whoſe baſe is a ſquare; and the form of its molecules is a triangular priſm, whoſe baſe is a right angled iſoſceles triangle, and the height is to any of the ſides of the baſe about the right angle as $\sqrt{12}$ to $\sqrt{5}$, or nearly as 3 : 2 ¶. Sometimes the cryſtals of titanium are ſix-ſided, and ſometimes four-ſided, priſms, and often they are implicated together ‡.

¶ Jour. de Min. N° xv. 28. and xxxii. 615.
‡ Fig. 44.

Colour red or browniſh red. Powder brick or orange red. Luſtre 3. Tranſparency commonly 0; ſometimes 1. Texture foliated. Hardneſs 9. Brittle. Sp. gr. from 4.18 * to 4.2469 †. Not affected by the mineral acids. When fuſed with carbonat of potaſs, and diluted with water, a white powder precipitates, heavier than the titanium employed. Before the blow-pipe it does not melt, but becomes opaque and brown. With microcoſmic ſalt it forms a globule of glaſs, which appears black; but its fragments are violet. With borax it forms a deep yellow glaſs, with a tint of brown. With ſoda it divides and mixes, but does not form a tranſparent glaſs.

* Klaproth.
† Vauquelin and Hecht.

When pure, it is compoſed entirely of oxyd of titanium.

species 2. Menachanite (x).

Oxyd of titanium combined with iron.

284
Menachanite.

This ſubſtance has been found abundantly in the valley of Menachan in Cornwal; and hence was called menachanite by Mr Gregor, the diſcoverer of it. It is in ſmall grains, like gunpowder, of no determinate ſhape, and mixed with a fine grey ſand. Colour black. Eaſily pulverized. Powder attracted by the magnet. Sp. gr. 4.427. Does not detonate with nitre. With two parts of fixed alkali it melts into an olive coloured maſs, from which nitric acid precipitates a white powder. The mineral acids only extract from it a little iron. Diluted ſulphuric acid, mixed with the powder, in ſuch a proportion that the maſs is not too liquid, and then evaporated to dryneſs, produces a blue coloured maſs. Before the blow-pipe does not decrepitate nor melt. It tinges microcoſmic ſalt green; but the colour becomes brown on cooling: yet microcoſmic ſalt does not diſſolve it. Soluble in borax, and alters its colour in the ſame manner.

According to the analyſis of Mr Gregor, it is compoſed of
46 oxyd of iron,
45 oxyd of titanium.

91 with ſome ſilica and mangaueſe †.

† M'Gregor, Jour. de Phyſ. xxxix. 72. 152.

According to Mr Klaproth's analyſis, it is compoſed of
51.00 oxyd of iron,
45.25 oxyd of titanium,
3.50 ſilica,
.25 oxyd of mangaueſe.

100.00 ‡

‡ Beiträge, ii. 231.

A mineral, nearly of the ſame nature with the one juſt deſcribed, has been found in Bavaria. Its ſpecific gravity, however, is only 3.7. According to the analyſis of Vauquelin and Hecht, it is compoſed of
49 oxyd of titanium,
35 iron,
2 mangaueſe,
14 oxygen combined with the iron and mangaueſe.

100 §

§ Jour. de Min. No xix. 57.

species 3. Calcareo ſiliceous ore of titanium.

Oxyd of titanium combined with lime and ſilica—Titanite †.

285
Calcareo-ſiliceous ore of titanium.

This ore has hitherto been found only near Paſſau. It was diſcovered by Profeſſor Hunger. It is ſometimes maſſive, but more commonly cryſtallized in four-ſided priſms, not longer than one fourth of an inch.

† Kirwan, ii. 331.

Colour reddiſh, yellowiſh, or blackiſh brown; ſometimes whitiſh grey. Powder whitiſh grey. Luſtre waxy or nearly metallic, 2 to 3. Tranſparency from 0 to 2. Texture foliated. Hardneſs 9 or more. Brittle. Sp. gr. 3.510. Muriatic acid, by repeated digeſtion, diſſolves one-third of it. Ammonia precipitates from this ſolution a clammy yellowiſh ſubſtance. Infuſible by the blow-pipe, and alſo in a clay crucible; but in charcoal is converted into a black opaque porous ſlag.

According to the analyſis of Klaproth, it is compoſed of
33 oxyd of titanium,
35 ſilica,
33 lime.

101

(v) *Dolomieu, Jour. de Min.* N° XLII. 431. and *Sauſſure, Voyages,* N° 1894.

(x) *Kirw.* II. 326.—*Gregor, Jour. de Phyſ.* XXXIX. 72. and 152.—*Schmeiſſer, Crell's Anna's* (Engliſh tranſlation), III. 252.

ORDER XX. ORES OF TELLURIUM.

HITHERTO tellurium has only been found in Tranſylvania. It occurs in three different mines; that of Fatzbay, Offenbanya, and Nagyag, which are conſidered as gold mines, becauſe they contain leſs or more of that metal. Its gangue is commonly quartz.

GENUS I. ALLOYS OF TELLURIUM.

286 G. I. Alloys. White gold ore of Fatzbay.

SPECIES 1. White gold ore of Fatzbay.

Alloy of tellurium and iron, with ſome gold.

This ſpecies is generally maſſive. Its colour is between tin white and lead grey. Luſtre conſiderable, metallic. Texture granular *.

According to Klaproth's analyſis, it is compoſed of

72.0 iron,
25.5 tellurium,
2.5 gold.

100.0 †

287 Graphic golden ore of Offenbanya.

SPECIES 2. Graphic golden ore of Offenbanya.

Tellurium alloyed with gold and ſilver.

This ore is compoſed of flat priſmatic cryſtals; the arrangement of which has ſome reſemblance to Turkiſh letters. Hence the name of the ore.

Colour tin white, with a tinge of braſs yellow ‡. Luſtre metallic, 3. Hardneſs 4 to 5. Brittle. Sp. gr. 5.723. Before the blow-pipe decrepitates, and melts like lead. Burns with a lively brown flame and diſagreeable ſmell, and at laſt vaniſhes in a white ſmoke, leaving only a whitiſh earth ‖.

According to Klaproth's analyſis, it is compoſed of

60 tellurium,
30 gold,
10 ſilver,

100 §

The yellow gold ore of Nagyag would belong to this ſpecies were it not that it contains lead. Its compoſition, according to Klaproth's analyſis, is as follows:

45.0 tellurium,
27.0 gold,
19.5 lead,
8.5 ſilver,

100.0 and an atom of ſulphur *

288 Grey foliated gold ore of Nagyag.

SPECIES 3. Grey foliated gold ore of Nagyag.

This ore is found in plates, of different degrees of thickneſs, adhering to one another, but eaſily ſeparable: theſe are ſometimes hexahedral, and often accumulated ſo as to leave cells between them.

Colour deep lead grey, paſſing to iron black, ſpotted. Luſtre metallic, moderate. Texture foliated; leaves ſlightly flexible †. Hardneſs 6. Sp. gr. 8.919. Stains the fingers. Soluble in acids with efferveſcence ‡.

According to Klaproth, it is compoſed of

50.0 lead,
33.0 tellurium,
8.5 gold,
7.5 ſulphur,
1.0 ſilver and copper.

100.0 §

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* Ann. de Chim. xxv. 327.

† Ibid. 280.

‡ Ann. de Chim. xxv. 328.

‖ De Born, Kirwan's Min. ii. 201.

§ Ann. de Chim. xxv. 280.

* Ibid.

† Klaproth, Ann. de Chim. xxv. 329.

‡ De Born, Kirwan's Min. ii. 99.

§ Ann. de Chim. ibid. 280.

ORDER XXI. ORES OF CHROMUM.

CHROMUM has hitherto been found in too ſmall quantities for its extenſive application to the arts. Whenever it becomes plentiful, its properties will render it of great importance both to the dyer and painter. Nature has uſed it to colour ſome of her moſt beautiful mineral productions: And can art copy after a better model? Hitherto it has been found only in two places, near Ekaterinbourg in Siberia, and in the department of the Var in France. In the firſt of theſe places, and probably alſo in the ſecond, its gangue is quartz.

GENUS I. SALTS OF CHROMUM.

289 G. I. Salts. Chromat of lead.

SPECIES 1. Chromat of lead.

Red lead ore of Siberia.

This ſingular mineral, which has now become ſcarce, is found in the gold mines of Bereſof near Ekaterimbourg in Siberia, cryſtallized in four-ſided priſms, ſometimes terminated by four-ſided pyramids, ſometimes not.

Colour red, with a ſhade of yellow. Streak and powder a beautiful orange yellow. Luſtre from 2 to 3. Tranſparency 2 to 3. Structure foliated. Texture compact. Fracture uneven. Hardneſs 5 to 4. Sp. gr. 6.0269 † to 5.75 ‡. Does not efferveſce with acids. Before the blow-pipe decrepitates; ſome lead is reduced, and the mineral is converted to a black ſlag, which tinges borax green.

According to the analyſis of Vauquelin, it is compoſed of

65.12 oxyd of lead,
34.88 chromic acid.

100.00 ‖.

290 Chromat of iron.

SPECIES 2. Chromat of iron.

This mineral, which has been found only near Gaſſin in the department of Var in France, is in irregular maſſes.

Colour brown, not unlike that of brown blende. Luſtre metallic. Hardneſs moderate. Sp. gr. 4.0326. Melts with difficulty before the blow pipe; to borax it communicates a dirty green. Inſoluble in nitric acid. Melted with potaſs, and diſſolved in water, the ſolution aſſumes a beautiful orange yellow colour.

It is compoſed of 63.6 chromic acid,
36.0 oxyd of iron.

99.6 †

CHAP. IV. OF THE CHEMICAL ANALYSIS OF MINERALS.

291 Analyſis of minerals.

THE progreſs which the art of analyſing minerals has made within theſe laſt twenty years is truly aſtoniſhing. To ſeparate five or ſix ſubſtances intimately combined together, to exhibit each of them ſeparately, to aſcertain the preciſe quantity of each, and even to detect the preſence and the weight of ſubſtances which do not approach $\frac{1}{100}$th part of the compound, would, at no very remote period, have been conſidered as a hopeleſs, if not an impoſſible, taſk; yet this can now be done with the moſt rigid accuracy.

292 Begun by Margraff.

The firſt perſon who undertook the analyſis of minerals was Margraff of Berlin. His attempts were indeed rude; but their importance was ſoon perceived by other chemiſts, particularly by Bergman and Scheele, whoſe induſtry and addreſs brought the art of analyſing minerals to a conſiderable degree of perfection.

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† Briſſon.

‡ Bindheim.

‖ Journ. de Min. N° xxxiv. 760.

† Taſſaert, Ann. de Chim. xxxi. 220.

293 Improved by Klaproth

294 And other chemiſts.

But their methods, though they had very conſiderable merit, and, conſidering the ſtate of the ſcience, are wonderful proofs of the genius of the inventors, were often tedious and uncertain, and could not in all caſes be applied with confidence. Theſe defects were perceived by Mr Klaproth of Berlin, who applied himſelf to the analyſis of minerals with a perſevering induſtry which nothing could fatigue, and an ingenuity and accuracy which nothing could perplex. He corrected what was wrong, and ſupplied what was wanting, in the analytical method; invented new proceſſes, diſcovered new inſtruments; and it is to his labours, more than to thoſe of any other chemiſt, that the degree of perfection, to which the analyſis of minerals has attained, is to be aſcribed. Many improvements, however, were introduced by other chemiſts, eſpecially by Mr Vauquelin, whoſe analyſes in point of accuracy and ingenuity rival thoſe of Klaproth himſelf.

We ſhall, in this chapter, give a ſhort deſcription of the moſt perfect method of analyſing minerals, as far as we are acquainted with it. We ſhall divide the chapter into four ſections. In the firſt, we ſhall give an account of the inſtruments uſed in analyſes; in the ſecond, we ſhall treat of the method of analyſing ſtones; in the third, of analyſing combuſtibles; and in the fourth, of the analyſes of ores.

Sect. I. *Of the Inſtruments of Analyſes.*

295 Method of obtaining chemical agents pure.

I. The chemical agents, by means of which the analyſis of minerals is accompliſhed, ought to be prepared with the greateſt care, becauſe upon their purity the exactneſs of the operation entirely depends. Theſe agents are the three alkalies, both pure and combined with carbonic acid; the ſulphuric, nitric, and muriatic acids; hydroſulphuret of potaſs and ſulphurated hydrogen gas diſſolved in water; pruſſic alkali, and a few neutral ſalts.

1. Potaſs and ſoda may be obtained pure, either by means of alcohol, or by the method deſcribed in the article Chemistry, n° 372. *Suppl.* Theſe alkalies are known to be pure when their ſolution in pure water occaſions no precipitate in lime and barytic water; when the precipitate which it produces in a ſolution of ſilver is completely diſſolved by nitric acid; and, laſtly, when ſaturated with carbonic acid it depoſits no ſilica.

2. Ammonia is procured by diſtilling one part of muriat of ammonia with two parts of quicklime, and receiving the gas in a diſh containing a quantity of pure water, equal in weight to the muriat employed. Its purity is known by the ſame teſts which aſcertain the purity of fixed alkalies.

3. The carbonats of potaſs and ſoda may be formed by diſſolving the potaſs and ſoda of commerce in pure water, ſaturating the ſolution with carbonic acid, and cryſtallizing them repeatedly. When pure, theſe cryſtals effloreſce in the air; and the precipitate which they occaſion in ſolutions of barytes and of ſilver is completely ſoluble in nitric acid. Carbonat of ammonia is obtained by diſtilling together one part of muriat of ammonia and two parts of carbonat of lime.

4. The ſulphuric acid of commerce often contains nitric acid, potaſs, lead, &c. It may be purified by diſtillation in a low cucurbite. The firſt portion, when it comes over, muſt be ſet aſide; it contains the nitric acid. The other impurities remain behind in the cucurbite. Sulphuric acid, when pure, diſſolves indigo without altering its colour, does not attack mercury while cold, and cauſes no precipitate in pure alkaline ſolutions.

5. Nitric acid often contains both ſulphuric and muriatic acids. It is eaſily purified by throwing into it about three parts of litharge in fine powder for every 100 parts of the acid, allowing the mixture to remain for 24 hours, ſhaking it occaſionally, and then diſtilling it. The ſulphuric and muriatic acids combine with the lead, and remain behind in the retort. Pure nitric acid occaſions no precipitate in the ſolutions of barytes and ſilver.

6. The muriatic acid of commerce uſually contains ſulphuric acid, oxymuriatic acid, and oxyd of iron. It may be purified by diſtillation with a little muriat of ſoda; taking care to ſet aſide the firſt portion which comes over. When pure it cauſes no precipitate in the ſolution of barytes, nor of pure alkalies, and does not attack mercury while cold.

7. Hydroſulphuret of potaſs is made by ſaturating a ſolution of pure potaſs with ſulphurated hydrogen gas; and water may be ſaturated with ſulphurated hydrogen gas in the ſame manner. See Chemistry, n° 857. *Suppl.*

8. The method of preparing pruſſic alkali, oxalic acid, and the other ſubſtances uſed in analyſes, has been already deſcribed in the article Chemistry, *Suppl.* it is unneceſſary therefore to repeat it here.

296 How to reduce the mineral to powder.

II. Before a mineral is ſubmitted to analyſis, it ought to be reduced to an impalpable powder. This is by no means an eaſy taſk when the ſtone is extremely hard. It ought to be raiſed to a bright red or white heat in a crucible, and then inſtantly thrown into cold water. This ſudden tranſition makes it crack and break into pieces. If theſe pieces are not ſmall enough, the operation may be repeated on each till they are reduced to the proper ſize. Theſe fragments are then to be beaten to ſmall pieces in a poliſhed ſteel mortar; the cavity of which ſhould be cylindrical, and the ſteel peſtle ſhould fit it exactly, in order to prevent any of the ſtone from eſcaping during the act of pounding. As ſoon as the ſtone is reduced to pretty ſmall pieces, it ought to be put into a mortar of rock cryſtal or flint, and reduced to a coarſe powder. This mortar ſhould be about four inches in diameter, and rather more than an inch in depth. The peſtle ſhould be formed of the ſame ſtone with the mortar, and care ſhould be taken to know exactly the ingredients of which this mortar is compoſed. Klaproth's mortar is of flint. We have given its analyſis in n° 32. of this article.

When the ſtone has been reduced to a coarſe powder, a certain quantity, whoſe weight is known exactly, 100 grains for inſtance, ought to be taken and reduced to as fine a powder as poſſible. This is beſt done by pounding ſmall quantities of it at once, not exceeding 10 grains. The powder is as fine as poſſible when it feels ſoft, adheres together, and as it were forms a cake under the peſtle. It ought then to be weighed exactly. It will almoſt always be found heavier after being pounded than it was before; owing to a certain quantity of the ſubſtance of the mortar which has been rubbed off during the grinding and mixed with the powder.

der. This additional weight muſt be carefully noted; and after the analyſis, a portion of the ingredients of the mortar, correſponding to it, muſt be ſubtracted.

297 Chemical diſhes

III. It is neceſſary to have a crucible of pure ſilver, or, what is far preferable, of platinum, capable of holding rather more than ſeven cubic inches of water, and provided with a cover of the ſame metal. There ſhould alſo be ready a ſpatula of the ſame metal about four inches long.

The diſhes in which the ſolutions, evaporations, &c. are performed, ought to be of glaſs or porcelain. Thoſe of porcelain are cheaper, becauſe they are not ſo apt to break. Thoſe which Mr Vauquelin uſes are of porcelain; they are ſections of ſpheres, and are glazed both within and without, except that part of the bottom which is immediately expoſed to the fire.

Sect. II. *Analyſis of Stones* (y).

298 Ingredients of ſtones.

The only ſubſtances which enter into the compoſition of the ſimple ſtones, as far at leaſt as analyſis has diſcovered, are the ſix earths, ſilica, alumina, zirconia, glucina, lime, and magneſia; and the oxyds of iron, mangaueſe, nickel, chromum, and copper (z). Seldom more than four or five of theſe ſubſtances are found combined together in the ſame ſtone: we ſhall ſuppoſe, however, in order to prevent unneceſſary repetitions, that they are all contained in the mineral which we are going to analyſe.

299 Method of decompoſing ſtones.

Let 100 or 200 grains of the ſtone to be analyſed, previouſly reduced to a fine powder, be mixed with three times its weight of pure potaſs and a little water, and expoſed in the ſilver or platinum crucible to a ſtrong heat. The heat ſhould at firſt be applied ſlowly, and the matter ſhould be conſtantly ſtirred, to prevent the potaſs from ſwelling and throwing any part out of the crucible. When the whole water is evaporated, the mixture ſhould be kept for half an hour or three quarters in a ſtrong red heat.

If the matter in the crucible melts completely, and appears as liquid as water, we may be certain that the ſtone which we are analyſing conſiſts chiefly of ſilica; if it remains opaque, and of the conſiſtence of paſte, the other earths are moſt abundant; if it remains in the form of a powder, alumina is the prevalent earth. If the matter in the crucible be of a dark or browniſh red colour, it contains oxyd of iron; if it is graſs green, mangaueſe is preſent; if it is yellowiſh green, it contains chromum.

When the crucible has been taken from the fire and wiped on the outſide, it is to be placed in a capſule of porcelain, and filled with water. This water is to be renewed from time to time till all the matter is detached from the crucible. The water diſſolves a part of the combination of the alkali with the ſilica and alumina of the ſtone, and if a ſufficient quantity were uſed, it would diſſolve the whole of that combination.

Muriatic acid is now to be poured in till the whole of the matter is diſſolved. At firſt a flaky precipitate appears, becauſe the acid combines with the alkali which kept it in ſolution. Then an efferveſcence takes place, owing to the decompoſition of ſome carbonat of potaſs formed during the fuſion. At the ſame time the flaky precipitate is rediſſolved; as is alſo that part of the matter which, not having been diſſolved in the water, had remained at the bottom of the diſh in the form of a powder. This powder, if it conſiſts only of ſilica and alumina, diſſolves without efferveſcence; but if it contains lime, an efferveſcence takes place.

If this ſolution in muriatic acid be colourleſs, we may conclude that it contains no metallic oxyd, or only a very ſmall portion; if its colour be purpliſh red, it contains manganeſe; orange red indicates the preſence of iron; and golden yellow the preſence of chromum.

This ſolution is to be poured into a capſule of porcelain, covered with paper, and evaporated to dryneſs in a ſand bath. When the evaporation is drawing towards its completion, the liquor aſſumes the form of jelly. It muſt then be ſtirred conſtantly with a glaſs or porcelain rod, in order to facilitate the diſengagement of the acid and water, and to prevent one part of the matter from being too much, and another not ſufficiently dried. Without this precaution, the ſilica and alumina would not be completely ſeparated from each other.

300 How the ſilica is ſeparated,

When the matter is reduced almoſt to a dry powder, a large quantity of pure water is to be poured on it; and, after expoſure to a ſlight heat, the whole is to be poured on a filter. The powder which remains upon the filter is to be waſhed repeatedly, till the water with which it has been waſhed ceaſes to precipitate ſilver from its ſolutions. This powder is the whole of the *ſilica* which the ſtone that we are analyſing contained. It muſt firſt be dried between folds of blotting paper, then heated red hot in a platinum or ſilver crucible, and weighed while it is yet warm. It ought to be a fine powder, of a white colour, not adhering to the fingers, and entirely ſoluble in acids. If it be coloured, it is contaminated with ſome metallic oxyd; and ſhews, that the evaporation to dryneſs has been performed at too high a temperature. To ſeparate this oxyd, the ſilica muſt be boiled with an acid, and then waſhed and dried as before. The acid ſolution muſt be added to the water which paſſed through the filter, and which we ſhall denominate A.

The watery ſolution A is to be evaporated till its quantity does not exceed 30 cubic inches, or nearly an Engliſh pint. A ſolution of carbonat of potaſs is then to be poured into it till no more matter precipitates. It ought to be boiled a few moments to enable all the precipitate to fall to the bottom. When the whole of the precipitate has collected at the bottom, the ſupernatant liquid is to be decanted off; and water being ſubſtituted in its place, the precipitate and water are to be thrown upon a filter. When the water has run off, the filter with the precipitate upon it is to be placed between folds of blotting paper. When the precipitate has acquired ſome conſiſtence, it is to be carefully collected by an ivory knife, mixed with a ſolution of pure potaſs, and boiled in a porcelain capſule. If any alumina or glucina be preſent, they will be diſſolved in the potaſs; while the other ſubſtances remain untouched in the form of a powder, which we ſhall call B.

(y) Part of this ſection is to be conſidered as an abſtract of a treatiſe of Vauquelin on the analyſis of ſtones, publiſhed in the *Annales de Chimie*, Vol. XXX. p. 66.

(z) Barytes has alſo been diſcovered in one ſingle ſtone, the *ſtaurolite*; but its preſence in ſtones is ſo uncommon, that it can ſcarcely be looked for. The method of detecting it ſhall be noticed afterwards.

301 And the alumina, Into the ſolution of potaſs as much acid muſt be poured as will not only ſaturate the potaſs, but alſo completely rediſſolve any precipitate which may have at firſt appeared. Carbonat of ammonia is now to be added in ſuch quantity that the liquid ſhall taſte of it. By this addition the whole of the alumina will be precipitated in white flcaks, and the glucina will remain diſſolved, provided the quantity of carbonat of ammonia uſed be not too ſmall. The liquid is now to be filtered, and the alumina which will remain on the filter is to be waſhed, dried, heated red hot, and then weighed. To ſee if it be really alumina, diſſolve it in ſulphuric acid, and add a ſufficient quantity of ſulphat or acetite of potaſs; if it be alumina, the whole of it will be converted into cryſtals of alum.

302 Glucina, Let the liquid which has paſſed through the filter be boiled for ſome time, and the glucina, if it contains any, will be precipitated in a light powder, which may be dried and weighed. When pure, it is a fine, ſoft, very light, taſteleſs powder, which does not concrete when heated, as alumina does.

303 Llime, The reſiduum B may contain lime, magneſia, and one or more metallic oxyds. Let it be diſſolved in weak ſulphuric acid, and the ſolution evaporated to dryneſs. Pour a ſmall quantity of water on it. The water will diſſolve the ſulphat of magneſia, and the metallic ſulphats; but the ſulphat of lime will remain undiſſolved. Let it be heated red hot in a crucible, and weighed. The lime amounts to 0.41 of the weight.

Let the ſolution containing the remaining ſulphats be diluted with a large quantity of water, let a ſmall exceſs of acid be added, and then let a ſaturated carbonat of potaſs be poured in. The oxyds of chromum, iron, and nickel, will be precipitated, and the magneſia and oxyd of mangaueſe will remain diſſolved. The precipitate we ſhall call C.

304 Mangaueſe, Into the ſolution let a ſolution of hydroſulphuret of potaſs be poured, and the manganeſe will be precipitated in the ſtate of a hydroſulphuret. Let is be calcined in contact with air, and weighed. 305 Magneſia, The magneſia may then be precipitated by pure potaſs, waſhed, expoſed to a red heat, and then weighed.

Let the reſiduum C be boiled repeatedly with nitric acid, then mixed with pure potaſs; and after being heated, let the liquid be decanted off. 306 romum, Let the precipitate, which conſiſts of the oxyds of iron and nickel, be waſhed with pure water; and let this water be added to the ſolution of the nitric acid and potaſs. That ſolution contains the chromum converted into an acid, Add to this ſolution an exceſs of muriatic acid, and evaporate till the liquid aſſumes a green colour; then add a pure alkali: The chromum precipitates in the ſtate of an oxyd, and may be dried, and weighed.

307 Iron, Let the precipitate, conſiſting of the oxyds of iron and nickel, be diſſolved in muriatic acid; add an exceſs of ammonia: the oxyd of iron precipitates. Let it be waſhed, dried, and weighed.

308 d nickel. Evaporate the ſolution, and the oxyd of nickel will alſo precipitate; and its weight may be aſcertained in the ſame manner with the other ingredients.

The weights of all the ingredients obtained are now to be added together, and their ſum total compared with the weight of the matter ſubmitted to analyſis. If the two are equal, or if they differ only by .03 or .04 parts, we may conclude that the analyſis has been properly performed: but if the loſs of weight be conſiderable, ſomething or other has been loſt. The analyſis muſt therefore be repeated with all poſſible care. If there is ſtill the ſame loſs of weight, we may conclude that the ſtone contains ſome ſubſtance, which has either evaporated by the heat, or is ſoluble in water.

309 Method of detecting volatile bodies. A freſh portion of the ſtone muſt therefore be broken into ſmall pieces, and expoſed in a porcelain crucible to a ſtrong heat. If it contains water, or any other volatile ſubſtance, they will come over into the receiver; and their nature and weight may be aſcertained.

If nothing comes over into the receiver, or if what comes over is not equal to the weight wanting, we may conclude that the ſtone contains ſome ingredient which is ſoluble in water.

310 Method of aſcertaining whether ſtones contain potaſs. To diſcover whether it contains *potaſs*, let the ſtone, reduced to an impalpable powder, be boiled five or ſix times in ſucceſſion, with very ſtrong ſulphuric acid, applying a pretty ſtrong heat towards the end of the operation, in order to expel the exceſs of acid; but taking care that it be not ſtrong enough to decompoſe the ſalts which have been formed.

Water is now to be poured on, and the reſiduum, which does not diſſolve, is to be waſhed with water till it becomes taſteleſs. The watery ſolution is to be filtered, and evaporated to dryneſs, in order to drive off any exceſs of acid which may be preſent. The ſalts are to be again diſſolved in water; and the ſolution, after being boiled for a few moments, is to be filtered and evaporated to a conſiſtence proper for cryſtallizing. If the ſtone contains a ſufficient quantity of alumina, and if potaſs be preſent, cryſtals of alum will be formed; and the quantity of potaſs may be diſcovered by weighing them, it being nearly $\frac{1}{10}$th of their weight. If the ſtone does not contain alumina, or not in ſufficient quantity, a ſolution of pure alumina in ſulphuric acid muſt be added. Sometimes the alum, even when potaſs is preſent, does not appear for ſeveral days, or even weeks; and ſometimes, when a great quantity of alumina is preſent, if the ſolution has been too much concentrated by evaporation, the ſulphat of alumina prevents the alum from cryſtallizing at all. Care, therefore, muſt be taken to prevent this laſt ſource of error. The alum obtained may be diſſolved in water, and barytic water poured into it as long as any precipitate forms. The liquor is to be filtered, and evaporated to dryneſs. The reſiduum will conſiſt of potaſs and a little carbonat of potaſs. The potaſs may be diſſolved in a little water. This ſolution, evaporated to dryneſs, gives us the potaſs pure; which may be examined and weighed.

311 Or ſoda. If no cryſtals of alum can be obtained, we muſt look for ſome other ſubſtance than potaſs. The ſtone, for inſtance, may contain ſoda. The preſence of this alkali may be diſcovered by decompoſing the ſolution in ſulphuric acid, already deſcribed, by means of ammonia. The liquid which remains is to be evaporated to dryneſs, and the reſiduum is to be calcined in a crucible. By this method, the ſulphat of ammonia will be volatilized, and the ſoda will remain. It may be rediſſolved in water, cryſtallized, and examined.

If ſulphuric acid does not attack the ſtone, as is often the caſe, it muſt be decompoſed by fuſion with ſoda, da, in the ſame manner as formerly directed with potaſs. The matter, after fuſion, is to be diluted with water, and then ſaturated with ſulphuric acid. The ſolution is to be evaporated to dryneſs, the reſiduum again diſſolved in water, and evaporated. Sulphat of ſoda will cryſtallize firſt; and by a ſecond evaporation, if the ſtone contains potaſs and alumina, cryſtals of alum will be depoſited.

The preſence of potaſs may be diſcovered, by mixing with a ſomewhat concentrated ſolution of muriat of platinum, the ſalt obtained, either by decompoſing the ſtone immediately by an acid, or by ſaturating with an acid the matter obtained by fuſing the ſtone with ſoda. If any potaſs be preſent, a very red precipitate will be formed. This precipitate is a triple ſalt, compoſed of potaſs, muriatic acid, and oxyd of platinum. Ammonia, indeed, produces the ſame precipitate; but ammonia has not hitherto been diſcovered in ſtones.

312 Analyſis of ſaline ſtones, In this manner may ſimple ſtones and aggregates be analyſed. As to ſaline ſtones, their analyſis muſt vary according to the acid which they contain. But almoſt all of them may be decompoſed by one or other of two methods; of each of which we ſhall give an example.

I. Analyſis of Carbonat of Strontites.

313 Of Carbonats, Klaproth analyſed this mineral by diſſolving 100 parts of it in diluted muriatic acid: during the ſolution, 30 parts of carbonic acid eſcaped. The ſolution cryſtallized in needles, and when diſſolved in alcohol, burnt with a purple flame. Therefore it contained ſtrontites. He diſſolved a grain of ſulphat of potaſs in ſix ounces of water, and let fall into it three drops of the muriatic ſolution. No precipitate appeared till next day. Therefore the ſolution contained no barytes; for if it had, a precipitate would have appeared immediately.

He then decompoſed the muriatic acid ſolution, by mixing it with carbonat of potaſs. Carbonat of ſtrontites precipitated. By the application of a ſtrong heat, the carbonic acid was driven off. The whole of the earth which remained was diſſolved in water. It cryſtallized; and when dried, weighed 69½ *.

II. Analyſis of Sulphat of Strontites.

Mr Vauquelin analyſed an impure ſpecimen of this mineral as follows:

314 Sulphats, On 200 parts of the mineral, diluted nitric acid was poured. A violent efferveſcence took place, and part of the mineral was diſſolved. The undiſſolved portion, after being heated red hot, weighed 167. Therefore 33 parts were diſſolved.

The nitric ſolution was evaporated to dryneſs: A reddiſh ſubſtance remained, which indicated the preſence of oxyd of iron. This ſubſtance was rediſſolved in water, and ſome ammonia mixed with it; a reddiſh precipitate appeared, which, when dried, weighed 1, and was oxyd of iron. The remainder of the ſolution was precipitated by carbonat of potaſs. The precipitate weighed, when dried, 20, and poſſeſſed the properties of carbonat of lime. Therefore 200 parts of this mineral contain 20 of carbonat of lime, 1 of oxyd of iron, and the remainder of the 33 parts he concluded to be water.

The 167 parts, which were inſoluble in nitric acid, were mixed with 500 parts of carbonat of potaſs, and 7000 parts of water, and boiled for a conſiderable time. The ſolution was then filtered, and the reſiduum waſhed and dried. The liquid ſcarcely efferveſced with acids; but with barytes it produced a copious precipitate, totally indiſſoluble in muriatic acid. Therefore it contained ſulphuric acid.

The undiſſolved reſiduum, when dried, weighed 129 parts. It diſſolved completely in muriatic acid. The ſolution cryſtallized in needles; when diſſolved in alcohol, it burnt with a purple flame; and, in ſhort, had all the properties of muriat of ſtrontites. Therefore theſe 129 parts were carbonat of ſtrontites. Now, 100 parts of this carbonat contain 30 of carbonic acid; therefore 129 contain 38.7. Therefore the mineral muſt contain in 200 parts 90.3 of ſtrontites.

Now, the inſoluble reſiduum of 167 parts was pure ſulphat of ſtrontites; and we have ſeen that it contained 90.3 of ſtrontites. Therefore the ſulphuric acid muſt amount to 76.7 parts †.

Nearly in the ſame manner as in the firſt of theſe examples, may the analyſis of carbonat of lime and barytes be performed; and nearly in the ſame manner with the ſecond, we may analyſe the ſulphats of lime and barytes.

315 Phoſphats, Phoſphat of lime may be diſſolved in muriatic acid, and the lime precipitated by ſulphuric acid, and its quantity aſcertained by decompoſing the ſulphat of lime obtained. The liquid ſolution may be evaporated to the conſiſtence of honey, mixed with charcoal powder, and diſtilled in a ſtrong heat. By this means phoſphorus will be obtained. The impurities with which the phoſphat may be contaminated will partly remain undiſſolved, and be partly diſſolved, in muriatic acid. They may be detected and aſcertained by the rules laid down in the ſecond ſection of this chapter.

316 Fluats, The fluat of lime may be mixed with ſulphuric acid and diſtilled. The fluoric acid will come over in the form of gas, and its weight may be aſcertained. What remains in the retort, which will conſiſt chiefly of ſulphat of lime, may be analyſed by the rules already laid down.

317 And borats. The borat of lime may be diſſolved in nitric or ſulphuric acid: The ſolution may be evaporated to dryneſs, and the boracic acid ſeparated from the reſiduum by means of alcohol, which will diſſolve it without acting on any of the other ingredients. The remainder of the dry maſs may be analyſed by the rules laid down in Sect. II. of this Chapter.

SECT. III. *Of the Analyſis of Combuſtibles.*

THE only combuſtibles of whoſe analyſis it will be neceſſary to ſpeak are coals and ſulphur; for the method of analyſing the diamond and oil has already been given in the article CHEMISTRY, *Suppl.*

318 Earths of coal how examined. Coal is compoſed of carbon, bitumen, and ſome portion of earth. The earths may be detected by burning completely a portion of the coal to be analyſed. The aſhes which remain after incineration conſiſt of the earthy part. Their nature may be aſcertained by the rules laid down in Sect. II. of this Chapter.

For the method of aſcertaining the proportion of carbon and bitumen in coal, we are indebted to Mr Kirwan.

319 Method of detecting the relative proportion of charcoal and bitumen. When nitre is heated red hot, and charcoal is thrown on it, a violent detonation takes place; and if the quantity of charcoal be ſufficient, the nitre is completely decompoſed. Now, it requires a certain quantity of pure

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* *Klaproth's Beiträge*, i. 260.

† *Jour. de Min.* No xxxvii. p. 4.

carbon to decompoſe a given weight of nitre. From the experiments of Lavoiſier, it follows, that when the detonation is performed in cloſe veſſels under water, 13.21 parts of charcoal are capable of decompoſing 100 parts of nitre*. But when the detonation is performed in an open crucible, a ſmaller proportion of charcoal is neceſſary, becauſe part of the nitre is decompoſed by the action of the ſurrounding air. Scheele found, that under theſe circumſtances 10 parts of plumbago were ſufficient to decompoſe 96 parts of nitre, and Mr Kirwan found, that nearly the ſame quantity of charcoal was ſufficient for producing the ſame effect.

Macquer long ago obſerved, that no volatile oily matter will detonate with nitre, unleſs it be previouſly reduced to a charcoal; and that then its effect upon nitre is preciſely proportional to the charcoal which it contains †. Mr Kirwan, upon trying the experiment with *vegetable pitch* and *maltha*, found, that theſe ſubſtances did not detonate with nitre; but merely burn upon its ſurface with a white or yellow flame; and that after they were conſumed, nearly the ſame quantity of charcoal was neceſſary to decompoſe the nitre which would have been required if no bitumen had been uſed at all ‡. Now coals are chiefly compoſed of charcoal and bitumen. It occurred therefore to Mr Kirwan, that the quantity of charcoal which any coal contains may be aſcertained by detonating it with nitre: For ſince the bitumen of the coal has no effect in decompoſing nitre, it is evident that the detonation and decompoſition muſt be owing to the charcoal of the coal; and that therefore the quantity of coal neceſſary to decompoſe a given portion of nitre will indicate the quantity of carbon which it contains: and the proportion of charcoal and earth which any coal contains being aſcertained, its bituminous part may be eaſily had from calculation.

The crucible which he uſed in his experiments was large; it was placed in a wind furnace at a diſtance from the flue, and the heat in every experiment was as equal as poſſible. The moment the nitre was red hot, the coal, previouſly reduced to ſmall pieces of the ſize of a pin head, was projected in portions of one or two grains at a time; till the nitre would no longer detonate; and every experiment was repeated ſeveral times to enſure accuracy.

He found, that 480 grains of nitre required 50 grains of Kilkenny coal to decompoſe it by this method. Therefore 10 grains would have decompoſed 96 of nitre; preciſely the quantity of charcoal which would have produced the ſame effect. Therefore Kilkenny coal is compoſed almoſt entirely of charcoal.

Cannel coal, when incinerated, left a reſiduum of 3.12 in the 100 parts of earthy aſhes. 66.5 grains of it were required to decompoſe 480 grains of nitre; but 50 parts of charcoal would have been ſufficient: therefore 66.5 grains of cannel coal contain 50 grains of charcoal, and 2.08 of earth; the remaining 14.42 grains muſt be bitumen. In this manner may the compoſition of any other coal be aſcertained.

320 Method of analyſing ſulphur.

As for ſulphur, in order to aſcertain any accidental impurities with which it may be contaminated, it ought to be boiled in thirty times its weight of water, afterwards in diluted muriatic acid, and laſtly in diluted nitro-muriatic acid. Theſe ſubſtances will deprive it of all its impurities without acting on the ſulphur itſelf, at leaſt if the proper cautions be attended to. The ſulphur may then be dried and weighed. The deficiency in weight will mark the quantity of the ſubſtances which contaminate the ſulphur. The ſolutions may be evaporated and examined, according to the rules laid down in the ſecond and fourth ſections of this chapter.

Sect. IV. *Of the Analyſis of Ores.*

321 No general method of analyſing ores.

The method of analyſing ores muſt vary conſiderably, according to the metals which they are ſuſpected to contain. A general method, therefore, of analyſing would be of no uſe, even if it could be given; becauſe it would be too complicated ever to be practiſed. We ſhall content ourſelves with exhibiting a ſufficient number of the analyſes of ores, to take in moſt of the caſes which can occur. He who wiſhes for more information on the ſubject, may conſult the treatiſe of Bergman on the *Analyſes of Ores*; Mr Kirwan's treatiſe on the ſame ſubject; and, above all, he ought to ſtudy the numerous analyſes of ores which have been publiſhed by Mr Klaproth.

I. Analyſis of Red Silver Ore.

322 Method of analyſing red ſilver ore.

Mr Vauquelin analyſed this ore as follows:

He reduced 100 parts of it to fine powder, poured over it 500 parts of nitric acid previouſly diluted with water, and applied a gentle heat to the mixture. The colour of the powder, which before the mixture with nitric acid was a deep purple, became gradually lighter, till at laſt it was pure white. During this change no nitrous gas was extricated; hence he concluded, that the metals in the ore were in the ſtate of oxyds.

When the nitric acid, even though boiled gently, did not appear to be capable of diſſolving any more of the powder, it was decanted off, and the reſiduum, after being carefully waſhed, weighed 42.06.

Upon theſe 42.06 parts concentrated muriatic acid was poured; and by the application of heat, a conſiderable portion was diſſolved. The reſiduum was repeatedly waſhed with muriatic acid, and then dried. Its weight was 14.6666. One portion of theſe 14.6666 parts, when thrown upon burning coals, burnt with a blue flame and ſulphureous ſmell. Another portion ſublimed in a cloſe veſſel without leaving any reſiduum. In ſhort, they had all the properties of ſulphur. Therefore 100 parts of red ſilver ore contain 14.6666 of ſulphur.

The muriatic acid ſolution was now diluted with a great quantity of water; it became milky, and depoſited a white flaky powder, which when waſhed and dried weighed 21.25. This powder, when heated with tartar in a crucible, was converted into a bluiſh white brittle metal, of a foliated texture, and poſſeſſing all the other properties of antimony. Red ſilver ore therefore contains 21.25 of oxyd of antimony.

The ſolution in nitric acid remained now to be examined. When muriatic acid was poured into it, a copious white precipitate appeared, which, when waſhed and dried, weighed 72.66. It had all the properties of muriat of ſilver. According to Mr Kirwan's tables, 72.66 of muriat of ſilver contain 60.57 of oxyd of ſilver. Therefore red ſilver ore, according to this analyſis, is compoſed of

60.57	oxyd of ſilver,
21.25	oxyd of antimony,
14.66	ſulphur.
96.48	

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* Mem. Sçav. Etrang. xi. 626.

† Macquer's *Dictionary*, 2d edit. p. 481.

‡ *Mineralogy*, ii. 522.

The loſs, which amounts to 3.52 parts, is to be aſcribed to unavoidable errors which attend ſuch experiments.

II. Antimoniated Silver Ore.

323 Analyſis of antimoniated ſilver ore.

Klaproth analyſed this ore as follows:

On 100 parts of the ore, reduced to a fine powder, he poured diluted nitric acid, raiſed the mixture to a boiling heat, and after pouring off the acid, added new quantities repeatedly, till it would diſſolve nothing more. The reſiduum was of a greyiſh yellow colour, and weighed, when dry, 26.

Theſe 26 parts he digeſted in a mixture of nitric and muriatic acid; part was diſſolved, and part ſtill remained in the form of a powder. This reſiduum, when waſhed and dried, weighed 13 parts. It had the properties of ſulphur; and when burnt, left a reſiduum of one part, which had the properties of ſilica. Antimoniated ſilver ore, therefore, contains, in the 100 parts, 12 parts of ſulphur and 1 of ſilica.

When the nitro-muriatic ſolution was diluted with about 20 times its weight of water, a white precipitate appeared; which, when heated to redneſs, became yellow. Its weight was 13. No part evaporated at a red heat: therefore it contained no arſenic. On burning coals, eſpecially when ſoda was added, part was reduced to a metal, having the properties of antimony; and in a pretty high heat, the whole evaporated in a grey ſmoke. Theſe 13 parts were therefore oxyd of antimony: They contain about 10 parts of metallic antimony; and as the ſtate of oxyd was produced by the action of the nitric acid, we may conclude, that antimoniated ſilver ore contains 10 parts of antimony.

The nitric acid ſolution remained ſtill to be examined. It was of a green colour. When a ſolution of common ſalt was poured in, a white precipitate was obtained, which poſſeſſed the properties of muriat of ſilver. When dried, it weighed 87.75 parts; and when reduced, 65.81 parts of pure ſilver were obtained from it. Antimoniated ſilver ore, therefore, contains 65.81 of ſilver.

Into the nitric acid ſolution, thus deprived of the ſilver, he dropped a little of the ſolution of ſulphat of ſoda; but no precipitate appeared. Therefore it contained no lead.

He ſuperſaturated it with pure ammonia, on which a grey precipitate appeared. When dried, it weighed 5 parts. This, on burning coals, gave out an arſenical ſmell. It was rediſſolved in nitric acid; ſulphurated alkali occaſioned a ſmutty brown precipitate; and pruſſic alkali a pruſſian blue, which, after torrefaction, was magnetic. Hence he concluded, that theſe 5 parts were a combination of iron and arſenic acid.

The nitric ſolution, which had been ſuperſaturated with ammonia, was blue; he therefore ſuſpected that it contained copper. To diſcover this, he ſaturated it with ſulphuric acid, and put into it a poliſhed plate of iron. The quantity of copper was ſo ſmall, that none could be collected on the iron.

III. Grey Copper Ore.

324 Analyſis of grey copper ore.

Klaproth analyſed this ore as follows:

Three hundred grains of it, not completely freed from its matrix, were reduced to a fine powder; four times their weight of nitric acid was poured on them, and the whole was digeſted. The acid was then poured off, and an equal quantity again digeſted on the reſiduum. The two acid ſolutions were mixed together. The reſiduum was of a yellowiſh grey colour, and weighed 188 grains.

On this reſiduum ſix times its weight of muriatic acid was boiled. The reſiduum was waſhed, firſt with muriatic acid, and afterwards with alcohol, and the waſhings added to the muriatic acid ſolution. The reſiduum, when dried, weighed 105.5 grains. Part of it burned with a blue flame; and was therefore ſulphur. The reſiduum amounted to 80.25 grains, and had the properties of ſilica. When melted with black flux, about $\frac{1}{4}$ths of a grain of ſilver were obtained from it. Thus 300 parts of grey copper ore contain 25.25 gr. of ſulphur, and 79.5 of ſilica.

The muriatic acid ſolution, which was of a light yellow colour, was concentrated by diſtillation, a few cryſtals of muriat of ſilver appeared in it, which contained about $\frac{1}{4}$th grain of ſilver. The ſolution, thus concentrated, was diluted with a great quantity of water; a white precipitate was depoſited, which, when dried, weighed 97.25 grains. It poſſeſſed the properties of oxyd of antimony, and contained 75 grains of antimony. Therefore 300 grains of grey copper ore contain 70 of antimony.

The nitric acid ſolution was of a clear green colour. A ſolution of common ſalt occaſioned a white precipitate, which was muriat of ſilver, and from which 31.5 grains of ſilver were obtained.

A little ſulphat of potaſs, and afterwards ſulphuric acid, were added, to ſee whether the ſolution contained lead; but no precipitate appeared.

The ſolution was then ſuperſaturated with ammonia; a looſe fleaky browniſh red precipitate appeared, which, when heated to redneſs, became browniſh black, and weighed 9$\frac{1}{3}$th grains. This precipitate was diſſolved in muriatic acid; half a grain of matter remained undiſſolved, which was ſilica. The muriatic acid ſolution, when pruſſic alkali was added, afforded a blue precipitate; and ſoda afterwards precipitated 1.5 grains of alumina. Therefore 300 grains of grey copper ore contain 7.25 grains of iron, and 1.5 of alumina.

Into the nitric ſolution ſuperſaturated with ammonia, and which was of an azure blue colour, a poliſhed plate of iron was put: By this method 69 grains of copper were obtained.

IV. Sulphuret of Tin.

325 Analyſis of ſulphuret of tin.

Klaproth analyſed this ore as follows*:

On 120 grains of the ore reduced to powder, ſix times their weight of nitro-muriatic acid, compoſed of 2 parts of muriatic, and 1 of nitric acid, were poured. There remained undiſſolved 43 grains, which had the appearance of ſulphur; but containing green ſpots, was ſuſpected not to be pure. After a gentle combuſtion, 13 grains remained; 8 of which were diſſolved in nitro-muriatic acid, and added to the firſt ſolution. The remaining 5 were ſeparated by the filtre, and heated along with wax. By this method about a grain of matter was obtained, which was attracted by the magnet; and which therefore was iron. The reſiduum weighed 3 grains, and was a mixture of alumina and ſilica. Thus 120 grains of ſulphuret of tin contain 30 grains of ſulphur, 1 of iron, and 3 of alumina and ſilica.

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* *Obſervations on the Foſſils of Cornwall*, p. 48.

The nitro-muriatic ſolution was completely precipitated by potaſs. The precipitate was of a greyiſh green colour. It was waſhed and dried, and again diſſolved in diluted muriatic acid. Into the ſolution a cylinder of pure tin was put, which weighed exactly 217 grains. The ſolution became gradually colourleſs, and a quantity of copper precipitated on the cylinder of tin, which weighed 44 grains. To ſee whether it was pure, a quantity of nitric acid was digeſted on it; the whole was diſſolved, except one grain of tin. Therefore 120 grains of ſulphuret of tin contains 43 grains of copper.

The cylinder of tin now weighed only 128 grains; ſo that 89 grains had been diſſolved. Into the ſolution a cylinder of zinc was put; upon which a quantity of tin precipitated. When waſhed and dried, it weighed 130 grains. The tin he melted with tallow and powdered charcoal; and when cold, he waſhed off the charcoal. Among the tin globules were found ſome black flocculi of iron, which weighed one grain. Deducting this grain, and the 89 grains of the tin cylinder which had been diſſolved, we ſee that the 120 grains of ſulphuret of tin contained 40 grains of tin beſides the grain which had been detected in the copper.

V. Plumbiferous Antimoniated Silver Ore.

326
Analyſis of plumbiferous antimoniated ſilver ore.

Klaproth analyſed this ore as follows:

He digeſted 400 grains of it, reduced to a fine powder, firſt in five times its weight of nitric acid, and then in twice its weight of the ſame acid. He then diluted this laſt portion of acid with eight times its weight of water, and continued the digeſtion. The undiſſolved reſiduum, when waſhed and dried, weighed 326 grains.

On this reſiduum he boiled muriatic acid repeatedly. The ſolution, on cooling, depoſited acicular cryſtals. Theſe he carefully ſeparated, and put by. The undiſſolved reſiduum weighed 51 grains. It had the properties of ſulphur. When burned, it left one grain of ſilica.

The muriatic acid ſolution was concentrated to half its former bulk by diſtillation: this made it depoſite more acicular cryſtals. He continued the diſtillation as long as any cryſtals continued to appear. He then collected the whole of theſe cryſtals together. They had the properties of muriat of lead. When mixed with twice their weight of black flux, and heated in a crucible lined with charcoal, they yielded 160⅛ grains of lead.

Sulphuret of ammonia was now added to the muriatic acid ſolution; an orange-coloured precipitate appeared, which ſhewed that the ſolution contained antimony. It was precipitated by a copious effuſion of water, and by ſoda. The oxyd of antimony being reduced to a maſs with Spaniſh ſoap, mixed with black flux, and heated in a lined crucible, yielded 28.5 grains of antimony.

Into the nitric acid ſolution, obtained by the firſt part of the proceſs, a ſolution of muriat of ſoda was dropped; a white precipitate was depoſited, and over it acicular cryſtals. Theſe cryſtals he diſſolved, by pouring boiling water on the precipitate. The water was added to the nitric acid ſolution. The white precipitate was muriat of ſilver: when heated with twice its weight of ſoda, it yielded 81.5 grains of ſilver.

He now concentrated the nitric acid ſolution by evaporation; and then adding a ſolution of ſulphat of ſoda, a white precipitate was obtained, which had the properties of ſulphat of lead, and weighed 43 grains. It contained 32 grains of pure lead.

He now poured ammonia into the ſolution; a pale brown precipitate was obtained, which weighed 40 grains, and which appeared to conſiſt of oxyd of iron and alumina. He rediſſolved it in nitric acid, precipitated the iron by pruſſic alkali, and the alumina by ſoda. The alumina, after being heated to redneſs, weighed 28 grains; conſequently the oxyd of iron was 12 grains, which is equivalent to 9 grains of iron.

VI. Molybdat of Lead.

327
Analyſis of molybdat of lead.

Mr Hatchett analyſed this ore as follows †:

On 250 grains of the ore, reduced to a fine powder, he poured an ounce of ſtrong ſulphuric acid, and digeſted the mixture in a ſtrong heat for an hour. When the ſolution was cool, and had ſettled, he decanted it off, and waſhed the undiſſolved powder with pure water, till it came away taſteleſs. This operation was repeated twice more; ſo that three ounces of ſulphuric acid were uſed. All theſe ſolutions were mixed together, and filtered.

Four ounces of a ſolution of carbonat of ſoda were poured upon the powder which remained undiſſolved, and which conſiſted of ſulphat of lead. The mixture was boiled for an hour, and then poured off. The powder was then waſhed, and diluted nitric acid poured on it: The whole was diſſolved, except a little white powder, which, when waſhed, and dried on a filter by the heat of boiling water, weighed ſeven-tenths of a grain. It poſſeſſed the properties of ſilica.

The nitric acid ſolution was ſaturated with pure ſoda; a white precipitate was obtained, which, when waſhed, and dried for an hour in a heat rather below redneſs, weighed 146 grains. It poſſeſſed the properties of oxyd of lead.

To ſee whether this oxyd of lead contained any iron, it was diſſolved in diluted nitric acid, and the lead precipitated by ſulphuric acid. The ſolution was then ſaturated with ammonia; a brown powder precipitated, which, when dried, weighed one grain, and had the properties of oxyd of iron.

The ſulphuric acid ſolution was of a pale blue colour: It was diluted with 16 times its weight of pure water, and then ſaturated with ammonia. It became of a deep blue colour, and appeared turbid. In 24 hours a pale yellow precipitate ſubſided, which, when collected on a filter, and dried by a boiling water heat, weighed 4.2 grains. Its colour was yellowiſh brown. Muriatic acid diſſolved it, and pruſſiat of potaſs precipitated it from its ſolution in the ſtate of pruſſian blue. It was therefore oxyd of iron.

The ſulphuric acid ſolution, ſaturated with ammonia, was gradually evaporated to a dry ſalt. This ſalt was a mixture of molybdat of ammonia and ſulphat of ammonia. A ſtrong heat was applied, and the diſtillation continued till the whole of the ſulphat of ammonia was driven off; and to be certain that this was the caſe, the fire was raiſed till the retort became red hot. The reſiduum in the retort was a black bliſtered maſs; three ounces of nitric acid, diluted with water, were poured upon it, and diſtilled off. The operation was again repeated. By this method the oxyd of molybdenum was converted into a yellow powder, which was yellow acid of molybdenum. It weighed 95 grains.

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† Phil. Tranſ. lxxxvi. 320.

VII. Grey Ore of Manganeſe.

328 Analyſis of grey ore of manganeſe.

Mr Vauquelin analyſed this ore as follows ‡:

When 200 grains of it were expoſed to a ſtrong heat in a retort, there came over 10 grains of water, and 18 cubic inches of oxygen gas, mixed with a little carbonic acid gas. The mineral now weighed only 176 grains. Therefore the weight of the gas was 14 grains.

On 200 grains of the ſame mineral muriatic acid was poured, and heat applied. 75 cubic inches of oxy muriatic acid gas came over, which, though mixed with ſome carbonic acid gas, enflamed metals when reduced to powder. When no more gas came over, the reſiduum was boiled. The whole was diſſolved, except a white powder, which weighed 12 grains, and which poſſeſſed the properties of ſilica.

Carbonat of potaſs was poured into the ſolution; a white precipitate was obtained, which became black by expoſure to the air, and weighed 288 grains. Strong nitric acid was boiled on it repeatedly to dryneſs. It became of a deep black colour, and, when well waſhed with water and dried, weighed 164 grains. This powder was black oxyd of manganeſe.

To ſee whether it contained iron, nitric acid, with a little ſugar, was poured upon it, and digeſted on it. The acid diſſolved it completely. Therefore no oxyd of iron was preſent.

Into the water with which the black oxyd of manganeſe had been waſhed, carbonat of potaſs was poured; a white powder precipitated, which, when dried, weighed 149 grains, and which poſſeſſed the poperties of carbonat of lime.

VIII. Wolfram.

329 Analyſis of wolfram.

Meſſrs Vauquelin and Hecht analyſed this mineral as follows:

On 200 parts of Wolfram in powder, three times its weight of muriatic acid were poured, and the mixture boiled for a quarter of an hour: a yellow powder appeared, and the ſolution was of a brown colour. The acid was allowed to cool, and then carefully decanted off, and the reſiduum waſhed. The reſiduum was then digeſted for ſome hours with ammonia, which diſſolved a part of it. The reſiduum was waſhed, and new muriatic acid again poured over it; then the reſiduum was digeſted with ammonia, as before: and the operation was continued till the whole wolfram was diſſolved.

All the ammoniacal ſolutions being joined together, were evaporated to dryneſs, and the ſalt which remained was calcined: a yellow powder was obtained; it weighed 134 grains, and was yellow acid of tungſten.

Into the muriatic acid ſolutions, which were all mixed together, a ſufficient quantity of ſulphuric acid was poured to decompoſe all the ſalts. The ſolution was then evaporated to dryneſs; and the ſalts which were obtained by this evaporation were rediſſolved in water. A white powder remained, which weighed three grains, and which poſſeſſed the properties of ſilica.

The exceſs of acid of the ſolution was ſaturated with carbonat of potaſs; the liquor became brown, but nothing precipitated. When boiled, a red powder precipitated, and the brown colour diſappeared. The addition of more carbonat of potaſs cauſed a farther precipitation of a yellowiſh powder. This precipitate conſiſted of the oxyds of iron and manganeſe combined. Nitric acid was diſtilled off it repeatedly; it was then boiled in acetous acid. The acetous ſolution was precipitated by potaſs. Nitric acid was again diſtilled off it, and it was again boiled in acetous acid. This proceſs was repeated till nitric acid produced no further change. The different powders which could not be diſſolved in the acetous acid were collected, mixed with a little oil, and heated red hot. The powder became black, and was attracted by the magnet. It was therefore oxyd of iron. It weighed 36 grains.

The acetous ſolution contained the oxyd of manganeſe: It was precipitated by an alkali, and, when dried, weighed 12.5 grains.

IX. Oxyd of Titanium and Iron.

330 Analyſis of oxyd of titanium and iron.

Vauquelin analyſed this ore as follows:

A hundred parts of the ore, reduced to a fine powder, and mixed with 400 parts of potaſs, were melted in a ſilver crucible for an hour and a half. When cool, the mixture was diluted with water; a powder remained of a brick red colour, which, when waſhed and dried, weighed 124 parts.

The watery ſolution had a fine green colour; when an exceſs of muriatic acid was added, it became red. By evaporation the liquor loſt its colour. When evaporated to dryneſs, a ſalt remained, which was totally diſſolved by water. From this ſolution carbonat of potaſs precipitated two parts, which had the properties of oxyd of manganeſe.

The 124 parts of reſiduum were boiled in a ſolution of pure potaſs for an hour. The ſolution was ſaturated with an acid, filtered, and carbonat of potaſs added, which precipitated three parts. Theſe had the properties of oxyd of titanium.

The remainder of the 124 parts of reſiduum, which ſtill was undiſſolved, was boiled with diluted muriatic acid. The liquor became yellow, and depoſited 46 parts of a white powder, with a tint of red. This powder was ſoluble in ſulphuric and muriatic acids: from theſe ſolutions, it was precipitated of a brick red colour by the infuſion of nut galls; of a green colour by ſulphuret of ammonia and pruſſiat of potaſs; and of a white colour by carbonat of potaſs and pure ammonia. A rod of tin made theſe ſolutions red; a rod of zinc made them violet. Theſe 46 parts, therefore, are oxyd of titanium.

The muriatic ſolution, from which theſe 46 parts were depoſited, formed, with pruſſiat of potaſs, a pruſſian blue; and ammonia precipitated from it 50 parts, which had the properties of yellow oxyd of iron.

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‡ Journ. de Min. No xvii. p. 12.

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Mirabeau.

MIRABEAU (Honnoré Gabriel, Comte de), well known both by his writings, and the active part which he took in bringing about the French revolution, was born in 1749 of a noble family. Throughout life, he diſplayed a ſpirit averſe from every reſtraint, and was one of thoſe unhappy geniuſes in whom the moſt brilliant talents ſerve only as a ſcourge to themſelves and all around them. It is told by his democratical panegyriſts, as a wonderful proof of family tyranny under the old government, that not leſs than 67 *lettres de cachet* had been obtained by Mirabeau the father againſt this ſon and others of his relatives. This ſtory, if true, proves, with at leaſt equal force, what many anecdotes confirm, that, for his ſhare of them, the ſon was not leſs indebted to his own ungovernable diſpoſition than to the ſeverity of his parent. He was indeed a monſter of wickedneſs. Debauchery, gaming, impiety, and every kind of ſenſuality, were not enough for him. He was deſtitute of decency in his vices; and to ſupply his expences, ſcrupled not to perform tricks which would diſgrace a thief-catcher. His father and mother diſagreeing, commenced a proceſs of ſeparation; when Mirabeau, juſt liberated from priſon for a groſs miſdemeanor, was in want of money He went to his father, ſided with him againſt his mother, on whom he poured a torrent of invectives; and, for 100 guineas, wrote his father's memorial for the court. He then went to his mother; and by a ſimilar conduct got the ſame ſum from her; and both memorials were preſented. That the father of ſuch a man ſhould frequently get him ſhut up in priſon, can excite no ſurpriſe; for confinement only could withhold him from the perpetration of crimes.

Mirabeau.

The talents of Mirabeau led him frequently to employ his pen; and his publications form the chief epochas of his life. His firſt publication was, 1. *Eſſai ſur le Deſpotiſme*, "An Eſſay on Deſpotiſm," in 8vo. Next, in one of his confinements, he wrote, 2. a work in 2 vols 8vo, *On Lettres de Cachet*. 3. *Conſiderations ſur l'Ordre de Cincinnatus*, 8vo. A remonſtrance againſt the order of Cincinnatus, propoſed at one time to be eſtabliſhed in America. The public opinion in America favoured this remonſtrance, and it proved effectual. 4. His next work was in favour of the Dutch, when Joſeph II. demanded the opening of the Scheldt, in behalf of the Brabançons. It is entitled, *Doutes ſur la Liberté de l'Eſcaut*, 8vo. 5. *Lettre à l'Empereur Joſeph II. ſur ſon Réglement concernant l'Emigration*; a pamphlet of forty pages, in 8vo. 6. *De la Caiſſe d'Eſcompte*; a volume in 8vo, written againſt that eſtabliſhment. 7 *De la Banque d'Eſpagne*, 8vo; a remonſtrance againſt eſtabliſhing a French bank in Spain. A

controverſy

Fig. 35.

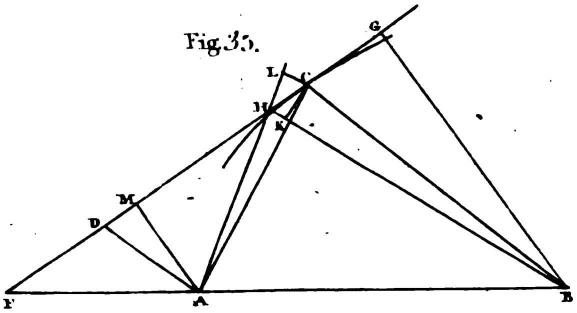


Fig 36.

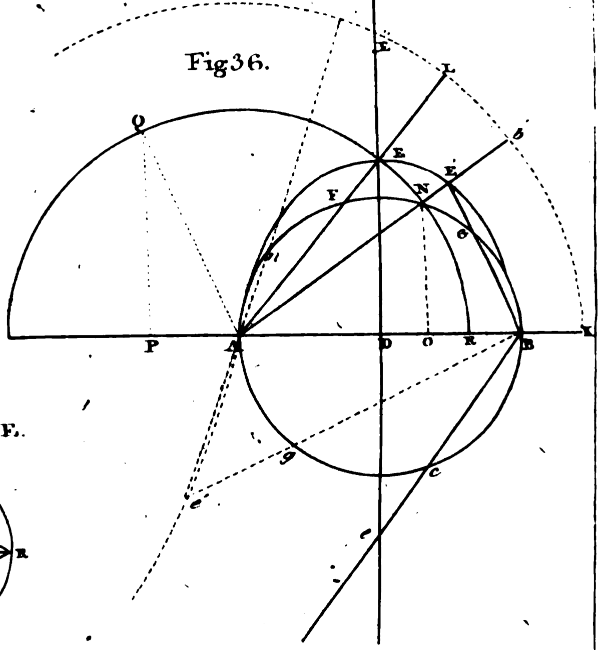
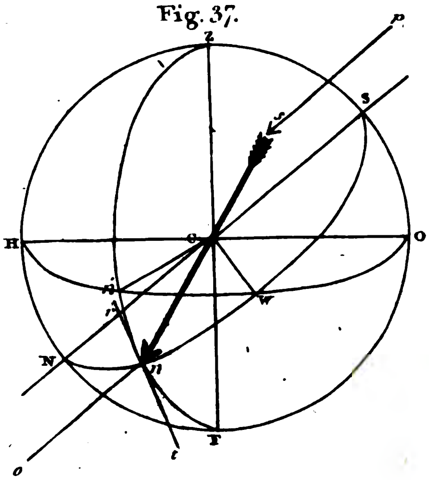
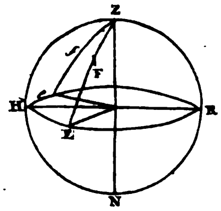


Fig. 37.



MERIDIAN LINE.



MINERALOGY.

Fig. 1.

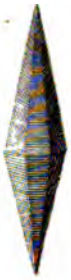


Fig. 2.

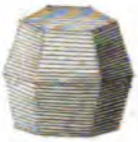


Fig. 3.

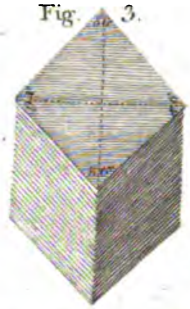


Fig. 4.

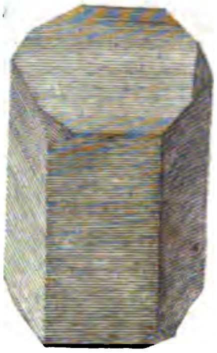


Fig. 5.

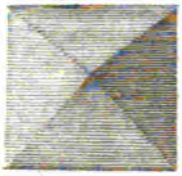


Fig. 6.

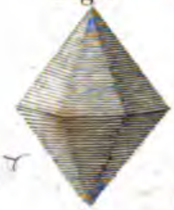
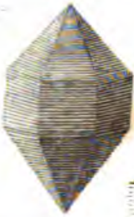


Fig. 7.



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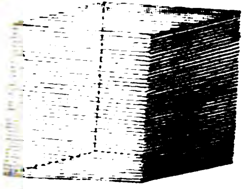

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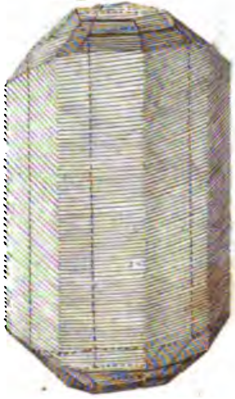

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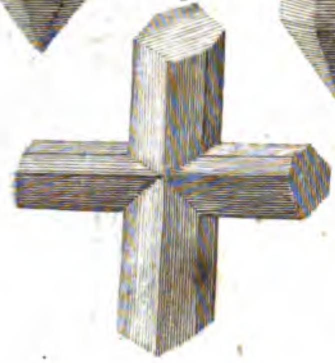

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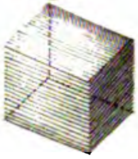

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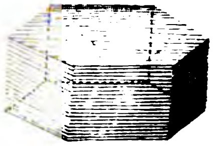

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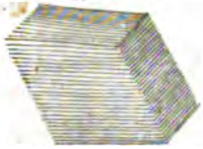

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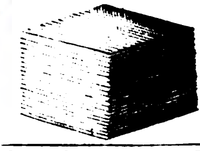

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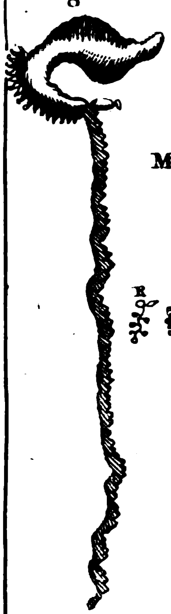
Fig. 1.



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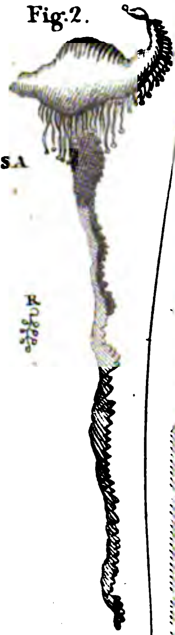
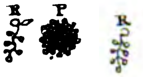
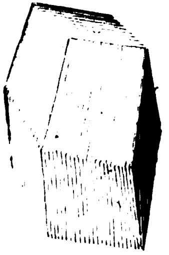




MINERALOGY PLATE XXXVII.

Fig: 20.



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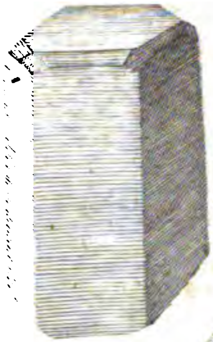

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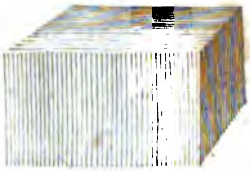

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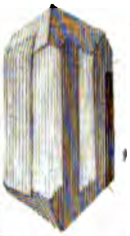

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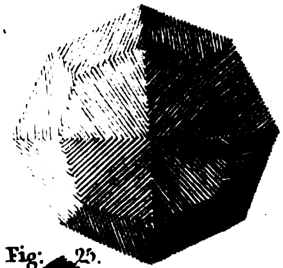

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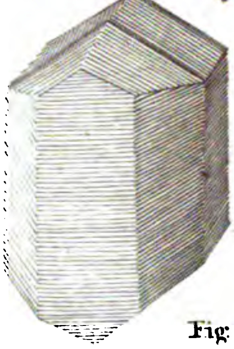

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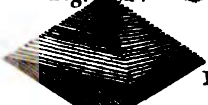

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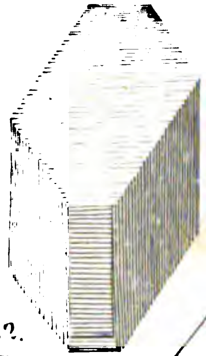

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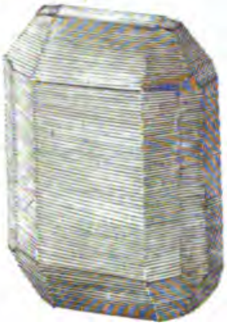

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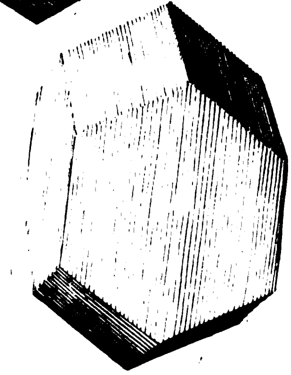

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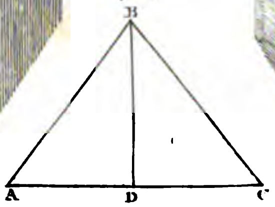

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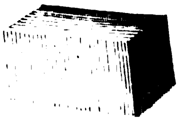

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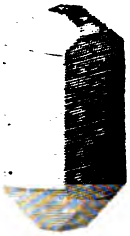

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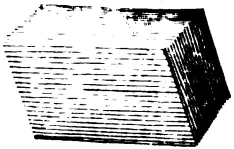

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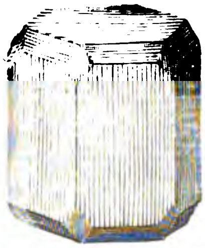

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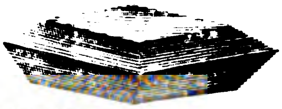

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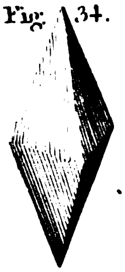

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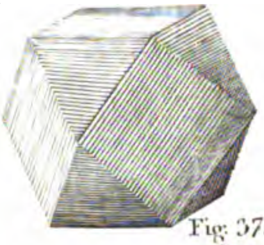

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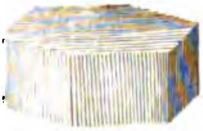

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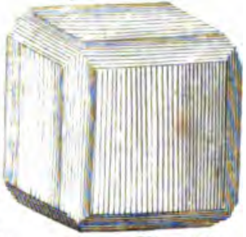

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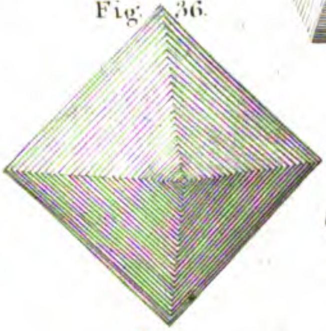

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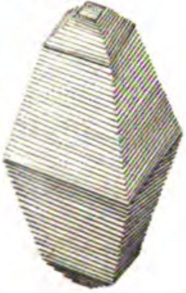

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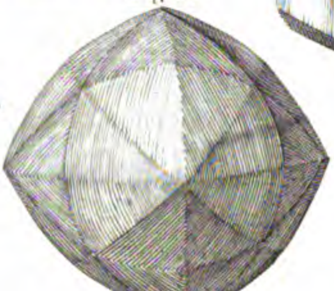

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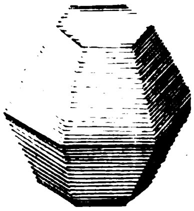

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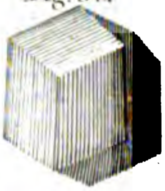

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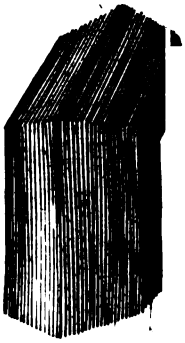

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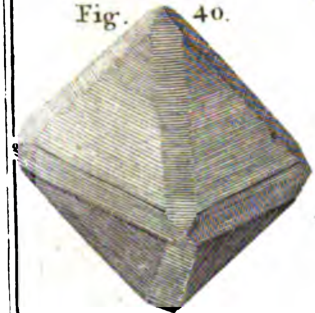

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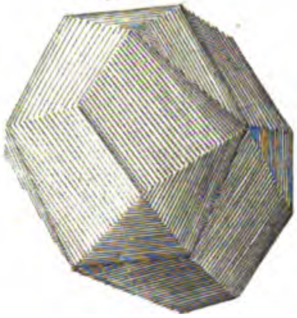

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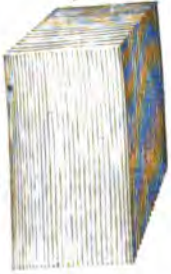

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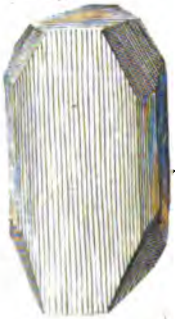

Lizars Sculpt

controverſy ariſing upon this ſubject, he wrote again upon it. 8. Two pamphlets on the monopoly of the water company in Paris.

Soon after the publication of theſe works, he was ſent in a public character to the court of Berlin; where he conducted the king's affairs juſt as he had formerly done thoſe of his father and mother, fully ready to ſacrifice all parties, and to ſell himſelf to the higheſt bidder. With ſuch a diſpoſition, he could not long avoid the notice of the Pruſſian illuminees; and Nicolai Bieſter, Gedicke, and Leuchſenring, ſoon became his conſtant companions. At Brunſwick he met with Mauvillon, the worthy diſciple of Philo Knigge, and at that time a profeſſor in the Caroline college. This was the man who initiated the profligate Marquis in the laſt myſteries of illuminiſm.

Mirabeau was ſtill at Berlin when Frederick II. died. That monarch, as is well known, was a naturaliſt, who, holding this life for his all, encouraged the propagation of infidelity in his dominions, from which reſulted the very worſt conſequences to the peace of ſociety. Of this truth his ſucceſſor Frederick William was duly ſenſible; and determined to ſupport the church eſtabliſhment in the moſt peremptory manner, conſiſtent with the principles of religious toleration. He publiſhed, therefore, ſoon after his acceſſion, an edict on religion, which is a model worthy of imitation in every country; but it was attacked with the greateſt virulence in numberleſs publications. It was called an unjuſtifiable tyranny over the conſciences of men; the dogmas ſupported by it were termed abſurd ſuperſtitions; the king's private character and his religious opinions were ridiculed and ſcandalouſly abuſed. The moſt daring of theſe attacks was a collection of anonymous letters on the conſtitution of the Pruſſian ſtates, univerſally believed to be the compoſition of Mirabeau, who certainly wrote a French tranſlation, with a preface and notes more impudent than the work itſelf. The monarch is declared to be a tyrant; the people of the Pruſſian dominions are addreſſed as a parcel of tame wretches, crouching under oppreſſion; and the inhabitants of Sileſia, repreſented as ſtill in a worſe condition, are repeatedly called upon to rouſe themſelves, and aſſert their rights.

About this time he publiſhed, 9. An *Eſſai ſur le Secte des Illuminés*; one of the ſtrangeſt and moſt impudent books that ever appeared. In it he deſcribes a ſect exiſting in Germany, called the *Illuminated*; and ſays, that they are the moſt abſurd and groſs fanatics imaginable, waging war with every appearance of reaſon, and maintaining the moſt *ridiculous ſuperſtitions*. He gives ſome account of theſe, and of their rituals and ceremonies, as if he had ſeen them all; yet no ſuch ſociety as he deſcribes ever exiſted: and Mirabeau employed his powers of deception, merely to ſcreen from obſervation the real *illuminati*, by holding out to the rulers of ſtates this *ignis fatuus* of his own brain. For a while the eſſay certainly contributed to blind the eyes of the German princes; and Nicolai, with others of the junto, adopting the whim, called Mirabeau's fanatics *Obſcuranten*, and joined with him in placing on the liſt of *Obſcuranten* ſeveral perſons whom they wiſhed to make ridiculous.

Long before his initiation in the myſteries of illuminiſm, Mirabeau had been acquainted with all the revolutionary powers of the maſonic lodges; nor did he, when initiated, undervalue thoſe which flowed, or might flow, from Weiſhaupt's inventive genius. On his return to France, he began to introduce the new myſteries among ſome of his maſonic brethren. His firſt aſſociate was the Abbé Talleyrand de Perigord, who had already begun to act the part of Judas in the firſt order of the church. But to have only introduced the myſteries was not ſufficient for the Marquis; he would have teachers come from Germany, who were better verſed than he was in the illuminizing arts. Well acquainted with the reaſons that had induced the chiefs of the order to defer the converſion of France, he found means to convince them, that the time was now come for the accompliſhment of their views; and at his requeſt a deputation was ſent by Spartacus to illuminize that great kingdom. See ILLUMINATI, nº 40, 41, *Suppl.*

When the aſſembly of Notables was convened at Paris, Mirabeau foretold that it would ſoon be followed by a meeting of the States; and at that period he publiſhed a volume againſt the ſtockjobbing, then carried to a great height, intitled, 10. *Denonciation de l'agiotage au Roi, et a l'Aſſemblée de Notables*, 8vo. A *lettre de cachet* was iſſued againſt him in conſequence of this publication; but he eluded purſuit, and publiſhed a pamphlet as a ſequel to the book. His next work was againſt M. Necker, 11. *Lettre á M. de Cretelle, ſur l'Adminiſtration de M. Necker*, a pamphlet in 8vo. 12. A volume, in 8vo. againſt the Stadtholderſhip: *Aux Bataves, ſur le Stadthouderat*. 13. *Obſervations ſur la maiſon de force appellé Bicetre*, an 8vo pamphlet. 14. Another tract, intitled, *Conſeils à un jeune Prince qui ſent la néceſſité de refaire ſon education*. 15. He now proceeded to a larger and more arduous work than any he had yet publiſhed, on the Pruſſian monarchy under Frederick the Great: *De la Monarchie Pruſſienne ſous Fréderic le Grand*, 4 vols, 4to, or eight in 8vo. In this work, he undertakes to define preciſely how a monarchy ſhould be conſtituted. When the orders were iſſued for convening the States general, Mirabeau returned into Provence; and at the ſame time publiſhed, 16. *Hiſtoire Secrette de la Cour de Berlin*, two volumes of letters on the Secret Hiſtory of the Court of Berlin. This work was condemned by the parliament of Paris, for the unreſerved manner in which it delivered the characters of many foreign princes. As the elections proceeded, he offered himſelf a candidate in his own order at Aix; but he was ſo abhorred by the nobleſſe, that they not only rejected him, but even drove him from their preſence. This affront ſettled his meaſures, and he determined on their ruin. He went to the commons, diſclaimed his being a gentleman, ſet up a little ſhop in the market-place of Aix, where he ſold trifles; and now, fully reſolved what line he ſhould purſue, he courted the commons, by joining in all their exceſſes againſt the nobleſſe, and was at laſt returned a member of the aſſembly.

In conſequence of this, he went to Paris; where the part he took was active, and ſuch as tended, in general, to accelerate all the violences of the revolution. He now publiſhed, periodically, 17. his *Lettres à ſes Commettans*, Letters to his Conſtituents; which form, when collected, 5 vols, 8vo. It is ſuppoſed, that the fatal meaſure of the junction of the three orders into one national

Mirabeau, Miſtral.

tional aſſembly, was greatly promoted by theſe letters. The public events of theſe times, and the part taken in them by Mirabeau, are the ſubject of general hiſtory. He lived to ſee the conſtitution of 1789 eſtabliſhed, but not to ſee its conſequences—the deſtruction of the monarchy, the death of the king, and the ruin of all property! He was accuſed, as well as the duke of Orleans, of hiring the mob which attacked Verſailles on the 5th and 6th of October 1789; but with him was alſo acquitted by the tribunal of the Châtelet. The dominion of his eloquence in the National Aſſembly had long been abſolute, and, on the 29th of January 1791, he was elected preſident. At the latter end of March, in the ſame year, he was ſeized by a fever, and died on the 2d of April.

The talents of Mirabeau will not be doubted, though they were certainly rather brilliant than profound. To be noticed, and to lead, were the ſole objects of his ambition; and for the attainment of them, he took the ſide of the diſcontented, as the beſt field for his matchleſs eloquence. Yet there was no man more devoted to the principles of a court than this Marquis, provided he could have a ſhare in the adminiſtration; and a ſhare he would have obtained, if any thing moderate would have ſatisfied him: But he thought nothing worthy of him but a place of active truſt, and a high department; ſtations which all knew him not qualified to fill. Wanting knowledge of great things, he was learned only in the buſtling detail of intrigue, and would, at any time, have ſacrificed his deareſt friend, and the intereſts of his country, for an opportunity of exerciſing his brilliant eloquence, and indulging his propenſity to ſatire and lampoon. But the greateſt obſtacle to his advancement under the old government was the abject worthleſſneſs of his character. Drinking was the only vice in which he did not indulge; and from this he was reſtrained by his exhauſted conſtitution. To his brother, the Viſcount, who was frequently intoxicated, the Marquis one day ſaid, "How can you, brother, ſo expoſe yourſelf?" "What (replied the Viſcount)! how inſatiable are you? Nature has given you every vice; and having left me only this one, you grudge it me!"

MISTRAL, the name of a wind, which is mentioned in almoſt every account that we have of Provence, and which is remarkable for blowing almoſt the whole year from north weſt or weſt-north-weſt, in a climate where the wind ſhould be variable. It is ſaid to contribute to the ſalubrity of the air, by diſperſing the exhalations of the marſhes and ſtagnant waters, ſo common in the ſouth of Languedoc and Provence; but at times it is alſo very injurious, or at leaſt very troubleſome. It is not, however, on either of theſe accounts that it is introduced into this Work, but for the ſake of the cauſes aſſigned by Sauſſure for its conſtancy, which may be applied to other winds that nearly reſemble it; and which he found might be reduced to three.

"The firſt and moſt effectual cauſe (he ſays) is the ſituation of the Gulf of Lyons, the banks of which are the principal theatre of its ravages. This Gulf, in fact, is ſituated at the bottom of a funnel, formed by the Alps and Pyrenees. All the winds blowing from any point between weſt and north, are forced by theſe mountains to unite in the Gulf. Thus, winds which would not have prevailed but at one extremity of the Gulf, or even much beyond it, are obliged to take this route, after having undergone the repercuſſion of theſe mountains; and the middle of the Gulf, inſtead of the calm which it might have enjoyed, is expoſed to the united efforts of two ſtreams of wind, deſcending in different directions. Hence ariſe thoſe whirlwinds which ſeem to characteriſe the miſtral, and appear to have induced the ancients to call it *Circius, à turbine ejus ac vertigine*. See *Aul. Gellius*, l. ii. cap. 22.

"The ſecond cauſe is, the general ſlope of the grounds, deſcending from all ſides towards the Gulf; which becoming all at once lower and more ſoutherly than the lands extending behind it, is, from theſe joint circumſtances, rendered the hotteſt point of all the adjacent country: and, as the air on the ſurface of the earth always tends from the colder to the warmer regions, the Gulf of Lyons is actually the centre towards which the air from all colder points between eaſt and weſt muſt preſs. This cauſe, then, alone would be productive of winds directed to the Gulf, even if the repercuſſion of the mountains did not exert its influence.

"Finally, it is well known, that in all gulfs the land-winds blow more forcibly than oppoſite to plains and promontories, whatever be the ſituation of theſe gulfs. I apprehend, indeed, on ſtrict examination (ſays our author), that this cauſe is blended with the preceding; but as the fact is generally admitted, and in ſome caſes can be explained only by reaſons drawn from the effects of heat, it may not improperly, perhaps, be diſtinctly mentioned. It is, at leaſt, neceſſary to ſuppoſe, that ſeveral cauſes produce the miſtral, in order to underſtand why, notwithſtanding the variableneſs of the ſeaſons and temperatures, that wind is ſo ſingularly conſtant in Lower Languedoc and Lower Provence. A very remarkable inſtance of this conſtancy is recorded by the Abbé Papon, in his *Voyage de Provence*, tom. ii. p. 81. He aſſerts, that during the years 1769 and 1770, the miſtral continued for fourteen months ſucceſſively. But the three cauſes which I have ſtated, taken ſeparately, will explain its frequency, and, united, will account for its force."

Miſtral ‖ Mœris.

MIXT Angle, or *Figure*, is one contained by both right and curved lines.

Mixt Number, is one that is partly an integer and partly a fraction; as $3\frac{1}{2}$.

Mixt Ratio, or *Proportion*, is when the ſum of the antecedent and conſequent is compared with the difference of the antecedent and conſequent;

$$\text{as if}\left\{\begin{array}{l} 4 : 3 :: 12 : 9 \\ a : b :: c : d \end{array}\right.$$

$$\text{then}\left\{\begin{array}{l} 7 : 1 :: 21 : 3 \\ a + b : a - b :: c + d : c - d. \end{array}\right.$$

MOCASSIMAH, in Bengal, revenue ſettled by a diviſion of the produce.

MOCHULKAH, bond or obligation.

MŒRIS, a lake in Egypt, occaſionally mentioned in that article (*Encycl.*), and generally ſuppoſed the production of human art. Of this, however, Mr Brown ſays it bears no mark. "The ſhape, as far as was diſtinguiſhable, ſeems not inaccurately laid down in D'Anville's map, unleſs it be, that the end neareſt the Nile ſhould run more in a north-weſt and ſouth-eaſt direction. The length may probably be between 30 and 40 miles; the breadth, at the wideſt part he could gain, was 5000 toiſes, as taken with a ſextant; that is, nearly ſix miles. The utmoſt poſſible extent of circuit muſt of courſe be 30 leagues. On the north-eaſt and ſouth is a rocky ridge, in every appearance primeval. In ſhort, nothing can preſent an appearance more unlike the works of men. Several fiſhermen, in miſerable boats, are conſtantly employed on the lake. The water is brackiſh, like moſt bodies of water under the ſame circumſtances. It is, in the language of the country, *Birket el-kerun*, probably from its extremities bearing ſome reſemblance to horns.

MOFUSSEL, a relative term, ſignifying the ſubordinate lands or diſtricts, oppoſed to Sudder, which is the head.

MOHACZ, Mohatz, or *Mohöz*, a town in the Lower Hungary, upon the Danube, between the river Sarwiza to the north, and the Drave to the ſouth; four German miles from either, ſix from Eſſeck to the north, and nine from Colocoa to the ſouth. This otherwiſe ſmall place is memorable for two great battles here fought; the firſt between Lewis king of Hungary and Solyman the Magnificent, in 1526: in which that unfortunate Prince Lewis (being about 20 years old), with 25,000 men, fought 300,000 Turks; when, being overpowered by numbers, 22,000 of the Chriſtian army were ſlain upon the place; 5000 waggons, eighty great cannon, 600 ſmall ones, with all their tents and baggage, were taken by the victors; and the King, in his flight over the brook Curaſs, fell into a quagmire, and was ſwallowed up. After which, Solyman took and ſlew 200,000 Hungarians, and got ſuch a footing in that kingdom, that he could never be expelled. This fatal battle was fought October 29. The ſecond, in ſome part, retrieves the loſs and infamy of the former. The Duke of Loraine being ſent by the Emperor, with expreſs orders to paſs the Drave and take Eſſeck, his highneſs, July 10, 1687, with great difficulty paſſed that river, then extremely ſwelled with rains; but finding the Prime Viſier encamped at Eſſeck, with an army of 100,000 men, ſo ſtrongly, that it was not poſſible to attack him in that poſt without the ruin of the Chriſtian army, he retreated, and repaſſed it the 23d of the ſame month; where, upon the 29th, the Prime Viſier paſſed that river at Eſſeck; and upon Auguſt 12th, there followed a bloody fight, in which the Turks loſt 100 pieces of cannon, 12 mortars, all their ammunition, proviſions, tents, baggage, and treaſure, and about 8000 men upon the place of battle, beſides what were drowned in paſſing the river, which could never be known. After which victory, General Dunewalt, September 30th, found Eſſeck totally deſerted by the Turks, and took poſſeſſion of it.

MOHER, in Bengal, a gold coin, worth about 33 ſhillings.

MOHERIR, a writer of accounts.

MOINEAU, a flat baſtion raiſed before a curtin when it is too long, and the baſtions of the angles too remote to be able to defend one another. Sometimes the moineau is joined to the curtin, and ſometimes it is divided from it by a moat. Here muſquetry are placed to fire each way.

MOLE (See Talpa, *Encycl.*), is an animal exceedingly troubleſome, both to gardeners and farmers; and there are perſons who contrive to make a livelihood by the trade of *mole-catching*. Theſe men, it is well known, are generally quacks and cheats; and the ſecrets which they ſell for extirpating thoſe deſtructive animals are of very little avail. Even poiſon ſeldom produces any conſiderable effect; becauſe the mole, while it does not drink, lives only on roots and worms. Under the word Mole (*Encycl.*), ſome directions will be found for clearing fields of this deſtructive animal; but the following are perhaps preferable, as they ſeem to have been the reſult of much experience:

Immediately at day-break, it will be neceſſary to make a tour round the garden or meadow, from which it is wiſhed to extirpate the moles; for at that time they will be all found at work, as may be ſeen by the hills newly thrown up. If the perſon is then cloſe to the hill, he muſt proceed as the gardeners do, and turn up with a ſtroke of the ſpade the hill together with the digger. The paſſage is then cut through before the animal is aware of the attack; and therefore it has not power to eſcape. If the mole-hill be freſh, even though the animal may not be throwing up earth, the perſon ought not to loſe his time in waiting, but ſhould immediately proceed to the operation above-mentioned.

If you find a freſh hill ſtanding by itſelf, which ſeems to ſhew by its ſituation that it has no communication with any other, which is always the caſe when the mole has worked from the ſurface downwards in endeavouring to procure a more convenient habitation, after the hill has been turned up with the ſpade, a bucket of water ſhould be poured over the mouth of the paſſage. By theſe means the animal, which is at no great diſtance, will be obliged to come forth, and may be eaſily caught with the hand.

You may diſcover alſo whether a hill has any communication with another, if you apply your ear to it, and then cough or make a loud noiſe. If it has no communication with the neighbouring hills, you will hear the terrified animal make a noiſe by its motion. It will then be impoſſible for it to eſcape; and you may either pour water into the hole, or turn up the hill with a ſpade, until the mole is found; for, in general, it never goes deeper into the earth than from fifteen to eighteen inches.

When any of the beds in a garden have been newly watered, the mole, attracted by the coolneſs and moiſture, readily repairs thither, and takes up its reſidence in them, making a paſſage at the depth of ſcarcely an inch below the ſurface. In that caſe it may eaſily be caught. When you ſee it at work, you need only tread behind the animal with your feet on the paſſage to prevent its retreat, and then turn up the hill with a ſpade; by which means you will be ſure to catch it.

When you dig after it with a ſpade, the animal forces its way downwards into the earth in a perpendicular direction, in order that it may the better eſcape the threatened danger. In that caſe it will not be neceſſary to dig long, but to pour water over the place, which will ſoon make the animal return upwards.

People, in general, are not aware of the great miſchief occaſioned in fields and gardens by theſe animals. We are, however, informed by Buffon, that in the year 1740 he planted fifteen or ſixteen acres of land with acorns, and that the greater part of them were in a little time carried away by the moles to their ſubterranean retreats. In many of theſe there were found half a buſhel, and in others a buſhel. Buffon, after this circumſtance, cauſed a great number of iron traps to be conſtructed; by which, in leſs than three weeks, he caught 1300. To this inſtance of the devaſtation occaſioned by theſe animals, we may add the following: In the year 1742 they were ſo numerous in ſome parts of Holland, that one farmer alone caught between five and ſix thouſand of them. The deſtruction occaſioned by theſe animals is, however, no new phenomenon. We are informed by hiſtory, that the inhabitants of the iſland of Tenedos, the Trojans, and the Æolians, were infeſted by them in the earlieſt ages. For this reaſon a temple was erected to Apollo Smynthius, the deſtroyer of moles. See *Economiſche Hefte*, Vol. VII. Part 5. and Vol IX. Part 4.; or *Phil. Magazine*, N° 5.

MOMENTS, in the new doctrine of infinites, denote the indefinitely ſmall parts of quantity; or they are the ſame with what are otherwiſe called infiniteſimals and differences, or increments and decrements; being the momentary increments or decrements of quantity conſidered as in a continual flux.

Moments are the generative principles of magnitude; they have no determined magnitude of their own, but are only inceptive of magnitude.

Hence, as it is the ſame thing if, inſtead of theſe moments, the velocities of their increaſes and decreaſes be made uſe of, or the finite quantities that are proportional to ſuch velocities; the method of proceeding which conſiders the motions, changes, or fluxions of quantities, is denominated by Sir Iſaac Newton, the *method of fluxions*.

Leibnitz, and moſt foreigners, conſidering theſe infinitely ſmall parts, or infiniteſimals, as the differences of two quantities, and thence endeavouring to find the differences of quantities, *i. e.* ſome moments, or quantities indefinitely ſmall, which taken an infinite number of times ſhall equal given quantities, call theſe moments differences; and the method of procedure, the differential calculus.

MONGEARTS, one of the tribes of wandering Arabs which inhabit the SAHARA, or Great Deſert of Africa. Their time is wholly occupied by tending their cattle; and becauſe they are little ſkilled in the uſe of arms, *Mongeart* is a term of contempt among the people by whom they are ſurrounded. Their country, with its produce, will be deſcribed under the title SAHARA in this *Supplement*; it is the buſineſs of this article merely to exhibit the manners of the people.

They are all Mahometans, and offer up prayers three times a-day, ſometimes oftener; but having no moſques, theſe prayers are never pronounced in public, except when the horde is viſited by a prieſt, who ſeldom comes but upon account of the childrens education. Then all the Arabs aſſemble at the hour of prayer, place themſelves in a line, turn to the eaſt, and, wanting water in the deſert, rub their face and arms with ſand; while the prieſt recites aloud the general prayer. It is the ſame as that which is rehearſed by the public crier in the moſques in civilized countries.

The prieſts are employed in travelling about the country to inſtruct the children. There is nothing like force in their education. The little boys meet in the morning of their own accord, at the place of inſtruction, which is to them a place of recreation. They go there with a ſmall board inſcribed with the Arabic characters, and a few maxims of the Koran. The oldeſt, and the beſt informed, receive their leſſons directly from the prieſts, and afterwards communicate them to their fellows. They are never corrected; becauſe it would be a crime to beat a child, who, according to the received notions, has not ſufficient reaſon to diſtinguiſh good from evil. This lenity extends even to the children of Chriſtians, though in a ſtate of ſlavery. They are treated in all reſpects like the children of Arabs; and the man who ſhould be raſh enough to ſtrike one of them, would endanger his life. Very different is their treatment of Negro children; who may indeed join in all the amuſements of the young Arabs, and even attend the public ſchools; but if they be guilty of a fault, they are ſeverely puniſhed.

When the child of a Mongeart becomes tired of the places of public inſtruction, he quits them at pleaſure, and, without feeling conſtraint, or hearing reproach, goes and employs himſelf in tending his father's flocks: and accordingly there are very few among them who can read. Thoſe who perſevere in the ſtudy of the Koran are made prieſts, after having paſt an examination before the learned elders, and enjoy the greateſt public conſideration. They have no need of cattle; for thoſe of the nation being theirs, they find their ſubſiſtence everywhere.

It is generally at ſeven or eight years of age that children undergo the painful operation of circumciſion. Their head is alſo ſhaved, nothing being left but four locks of hair; one of which is cut off in a meeting of the family, at each remarkable action performed by the child. If, at the age of 12 or 13, he kill a wild boar, or other beaſt of prey, that ſhould fall upon his flock, he loſes one of his locks. If, in the paſſage of a river, a camel be carried away by the ſtream, and he ſave it by ſwimming to its aſſiſtance, another is cut off. If he kill a lion, a tiger, or a warrior of an hoſtile nation, in a ſurpriſe or an attack, he is conſidered as a man, and his head is entirely ſhaved.

Different from the other Arabs their neighbours, and indeed from the Mahometans in general, the Mongearts trouble no man on account of his religion. The only one which they do not tolerate is the Jewiſh; and were a Jew to enter their territory, and have the miſfortune to be taken, he would certainly be burnt alive.

According to M. Saugnier, the women are much more reſpected among the Mongearts than among the neighbouring nations; but the evidences which he gives of that reſpect are very extraordinary.

When a Mongeart is deſirous of undertaking the care of a family, he pitches upon the girl that pleaſes him the moſt, and aſks her of her father without further formality; nor can the latter refuſe her, unleſs the man who pretends to her hand have done ſomething contrary to the laws of the nation. The girl is conducted by her parents to the tent of her future huſband, where there is always an abundant repaſt prepared for the ceremony. Preſents are made to the father; but if the ſon-in law be poor, his wife's family aſſiſt him, and furniſh him with the means of increaſing his flocks; if, on the contrary, he be rich, and the father poor, he ſupports the whole family in his own tent. The employment of the wife, thus married, is to prepare the food; to ſpin the goats and camels hair, of which the tents are made; to milk the cattle; to pick up the neceſſary ſupply of wood for the night; and when the hour of repaſt is come, to wait upon her huſband. She

Mongeart.

then eats by herſelf what has been left by him and his male ſlaves. She is, indeed, in no great danger of having a rival brought into the family; for though polygamy be allowed by his religion, the poverty of the Mongeart generally prevents him from taking a plurality of wives. She is, however, liable to be divorced at will when ſhe does not bear boys; but if ſhe have the good fortune to have one or more male children, her huſband's regard for her is inconceivable. She has no longer a divorce to fear, has an abſolute authority in the tent, and paſſes her whole time in converſation, ſleep, or dancing, as ſhe thinks fit. The captive negreſſes do all her work, and are no longer aſſiſted in their labour by the Arab's wife, who treats them, on the contrary, with the greateſt harſhneſs and arrogance.

When a woman is not agreeable to her huſband, or when he is diſagreeable to her, they have it in their power to part. The formality in this caſe conſiſts in the wife's retiring to her parents. If the huſband be attached to her, he goes thither in queſt of her; but if ſhe perſiſt in refuſing to return, ſhe is free, and at liberty to marry another. If, however, ſhe have had a child, eſpecially a boy, ſhe has not the ſame privilege; in that caſe, if her retreat ſhould laſt more than eight days, it might be puniſhed with death.

When a man beats his wife, it is a ſure ſign that he is ſincerely attached to her, and that he does not mean to part with her; if he content himſelf with reproaches, the wife thinks herſelf deſpiſed, and infallibly retires to her parents. Hence it is, that in the moſt trifling diſputes the women are cruelly beaten: they prefer it to the complaints that the huſband might make to their parents; this proof being the moſt certain one of a man's fondneſs for his wife. When a girl marries, ſhe makes up her mind to ſuch treatment, deeming it much more ſupportable than the humiliations ſhe would otherwiſe experience from her family, in conſequence of her huſband's complaints.

The conjugal fidelity of the Mongeart women is incorruptible. Differing in their opinions from many other Mahometans, they believe themſelves immortal like the men; but they do not flatter themſelves with the poſſibility of happineſs in the other world, unleſs they ſhall have been faithful to their huſbands in this. Women, who have been falſe to their huſband's bed, will be doomed, they think, to eternal ſlavery to the more virtuous part of their ſex, without ever partaking, in the ſmalleſt degree, of their bliſs.

Mongeart women often viſit one another; and on theſe occaſions, the honour conſiſts in letting the female who comes to ſee her friend or relation do all the work of the tent. The viſitor aſſumes the management of every thing, dreſſes the victuals, churns the butter, and keeps herſelf continually employed; while her friend entertains her with an account of the different affairs of the family or nation. The heartineſs of the welcome is meaſured by the extent of the work ſubmitted to the gueſt, who generally prepares double the uſual quantity of food; ſo that the Arab is obliged to invite his neighbours to partake of the repaſt. The ſlaves are always pleaſed with theſe entertainments, a larger portion then coming to their lot. It is the buſineſs of the viſitor to do the honours; nor will ſhe ſuffer any body about her to remain diſſatisfied.

Mongearts.

The laws of hoſpitality are obſerved among the Mongearts as among all the wandering Arabs. Indeed they are carried to ſuch a length, that were a man to enter the tent of him whom he had wounded, or even killed, he would there meet with a ſacred and inviolable aſylum, although ſurrounded by thoſe who muſt naturally deſire his ruin. The tent of the chief is always that to which ſtrangers, upon their arrival in the horde, are directed. But the chief could not entertain, at his own expence, all the ſtrangers that happen to paſs; and therefore every tent in the horde is obliged to furniſh him with two pounds of ground barley *per* week, to enable him to maintain the ancient hoſpitality.

The chiefs of hordes are always the eldeſt of their families. The difference of wealth is not conſidered; the chief often having ſeveral individuals at his houſe richer than himſelf, who nevertheleſs obey him in every particular. He is, properly ſpeaking, their king; examines their difference with the old men, and judges without appeal. As to himſelf, he cannot be tried but by the chiefs of ſeveral hordes aſſembled. It is his buſineſs to determine the ſpots where the tents are to be pitched, the moment of departure, and the place where the caravan is to ſtop. If the paſturage do not ſuffice for the herds of all the horde, it divides, and the chief aſſigns the ground for the different encampments. They are very often compoſed of no more than ſeven or eight tents, according to the quality of the ground they meet with. The tent of the chief is always the largeſt and moſt lofty, and is placed in the centre of the diviſions. When it is determined upon to quit an encampment, which never happens till the paſture is exhauſted, the chief ſets off to chooſe another ſpot. In theſe removals the women alone do all the work. Early in the morning they fold up the tent, and load every thing upon the camels backs; they then move ſlowly on, that the cattle may have time to feed upon the way.

Great reſpect is paid by the Mongearts to all old men, who enjoy the ſame prerogatives as the prieſts, and ſuch Arabs as have viſited the tomb of Mahomet at Mecca. Together with the chief they are the judges of the horde, and take cognizance of all offences, the pain of death being the only puniſhment which they cannot decree. An aſſembly of ſeveral chiefs is the only tribunal which can inflict capital puniſhment; but as the accuſed has generally a number of friends, it ſeldom happens that he is capitally convicted.

A war between two Mongeart tribes ſeldom happens, and is never bloody; but the different families deſtroy one another faſt enough in their inteſtine broils. They are all thieves; and indeed theft is a crime only in the day-time, being authoriſed by law during the night, in order to compel them to take care of their cattle. Could they find redreſs when robbed by night, they would be leſs vigilant; and their herds and flocks would be more expoſed to the wild beaſts that over-run their country; but being obliged to be on their guard even againſt their neareſt neighbours, they are always ready to repel both the lion and the tiger. Theft, even in the day-time, is ſo far from being puniſhed, unleſs detected at the inſtant of commiſſion, that when any thing is ſtolen unperceived, it becomes the lawful property of the thief. In vain would the rightful owner recognize it in his neighbour's tent; he cannot reclaim it; it ceaſes to be his from the moment he has been negligent in its care. Hence ariſes this peoples inclination for rapine:

they do not think they commit a crime, and only follow, in this regard, a cuſtom allowed by their laws.

When an Arab is going to market, or on his return from thence, if he do not take the greateſt care to keep his journey a ſecret, he is often attacked. Neighbouring Arabs are deſirous of profiting by his induſtry; and as there are no perſons in the country appointed to apprehend robbers, the hope of booty ſpurs them on to the attack. That they may have nothing to fear, they lie in wait, when the night is coming on, for him whom they mean to pillage. Their intention is never to kill; they only endeavour to ſurprize, to diſarm, and to make themſelves maſters of every thing that comes in their way. But it ſometimes happens, that the man they intend to plunder, being acquainted with the cuſtoms of his country, keeps an attentive ear, ſtands on his guard, fires upon his aſſailants at the firſt motion he obſerves, and then fights deſperately with his dagger. The report of the muſket almoſt always brings out the neighbouring Arabs, who, in virtue of the laws of hoſpitality, take the defence of the weaker ſide. They run up well armed; and then woe to the aggreſſors, if they do not ſave themſelves by a ſpeedy flight.

The flocks and herds of the Mongearts are compoſed of nothing but ſheep, goats, and camels; all animals patient of thirſt. Horſes are very ſcarce in theſe cantons, none but the poſſeſſors of numerous herds being able to keep them; becauſe, for want of water, it is neceſſary to have milk in ſufficient abundance to give it them to drink. Great care is taken to preſerve the camel's urine, both to mix with milk, and to waſh the different veſſels in which they put their food. Deteſtable as is this mixture of milk and urine, they are often reduced to the uſe of it; hunger and thirſt give a reliſh to every thing.

The only workmen uſeful to this nation are blackſmiths or goldſmiths, as they may be called indifferently. The Mongearts not being ſufficiently laborious to apply themſelves to ſuch occupations, theſe workmen come from Bilidulgerid, and diſperſe themſelves all over the different parts of the deſert. Wherever there are tents they are ſure to find work. They are fed for nothing, and receive beſides the hire for their labour. They make trinkets for the women, ſuch as ear-rings and bracelets, &c. mend the broken veſſels, by rivetting them, and clean the arms. They are generally paid in ſkins, goats and camels hair, or oſtrich feathers, according to their agreement. Thoſe who have ſilver pay them a tenth part of its weight for any thing wrought out of that metal. On their return they ſell what they have earned; four or five excurſions at moſt enabling them to live afterwards at their eaſe in their own country.

The Mongearts always carry a leathern bag, ſuſpended from their neck, in which they put their tinder, their pipe, and their tobacco. Their daggers are elegant; the hilt is always black, and inlaid with ivory; the blade is crooked, and ſharp on either ſide; the ſheath is of braſs on one ſide, and of ſilver on the other, and of very tolerable workmanſhip. They wear ſabres when they can get them, and prefer thoſe of Spaniſh make. Their muſkets are always highly ornamented; the ſtock is very ſmall, and inlaid on every ſide with ivory, and the barrel emboſſed with braſs or ſilver, according to the opulence of the owner. There is a ſpring to the lock, covering the priming, to prevent the piece from going off, contrary to the intention of him who carries it. The poor, who do not poſſeſs muſkets, wear daggers, made like the Flemiſh knives, with leathern ſheaths. They arm themſelves alſo with a thick ſtick, to the end of which they fix a kind of iron wedge. This weapon is exceedingly dangerous at cloſe quarters. Others carry *zagays*, or ſlender javelins. In a word, the principal riches of an Arab, and his higheſt gratifications, are a handſome muſket and a good dagger. He prefers them to neatneſs of apparel; for as to dreſs, it is indifferent to him whether he be clothed in Guinea blues, woollen ſtuffs, or goats ſkins. Their arms being their principal ornament, they take particular care to put the muſkets in leathern bags, by way of keeping them in good order, and preſerving them from the ruſt.

All the riches of the Mongearts conſiſt in their herds; and accordingly they take the greateſt care to preſerve them. If a beaſt be ſick, every thing is done to cure it; no care is ſpared; it is even treated with more attention than a man: but when it evidently appears that there is no hope of ſaving its life, they kill and eat it. If it be a camel, the neighbours are called in to partake of the repaſt; if a goat, the inhabitants of the tent ſuffice for its conſumption. An animal that dies without ſhedding blood is unclean. Its throat muſt be cut; the perſon who kills it turning to the eaſt, and pronouncing beforehand the firſt words of the general prayer. An animal killed by a wild boar is unclean; nor is it eaten although its blood has been ſhed, becauſe the wild boar is itſelf an unclean beaſt. That ſpecies is ſo numerous in the deſart, that they do more miſchief than all the other wild beaſts together. The Arabs kill as many as they can; but never taſte their fleſh.

Whatever loſſes an Arab may meet with, he is never heard to complain; he riſes ſuperior to poverty, ſupports hunger, thirſt, and fatigue, with patience, and his courage is proof againſt every event. God will have it ſo, ſays he: he employs, however, every means in his power to avert miſfortune; and often expoſes himſelf to the greateſt dangers to procure matters of no real utility.

When a father of a family dies, all the effects in his tent are ſeized upon by the eldeſt ſon preſent at his deceaſe. Gold, ſilver, trinkets, every thing diſappears; and the abſent children have only an equal ſhare in the diviſion of the cattle and the ſlaves. The girls are entirely excluded from all participation, and take up their reſidence with their eldeſt brother. If the deceaſed leave children in helpleſs infancy, the mother takes them with her to her ſiſter's, if ſhe have a ſiſter married; if not, to her own maternal roof. The dead man's poſſeſſions, however, are not loſt; the chief of the horde takes care of them, and delivers them in equal portions to the heirs, as ſoon as they are old enough to manage their own property. If an Arab die without male children, his wife returns to her relations, and his brother inherits his effects.

The Mongearts have a rooted abhorrence of the Spaniards, and never fail to maſſacre every man of that nation who is ſo unfortunate as to be ſhipwrecked on their coaſts, while they reſerve the women for ſale at Morocco. The reaſon of this hatred is, that the inhabitants of the Canaries make frequent deſcents on the Mongeart coaſts, and carry off men, women, cattle, and every thing that they meet with; and theſe people, being ignorant of the fate of their countrymen, retaliate by death on all Spaniards that fall into their hands, whilſt they treat the Britiſh and French as well as they can.

MONNIER (Peter Charles Le), was born at Paris on the 20th of November 1715. The profeſſion of his father, or the rank which he held in ſociety, we have not learned; and we are equally ignorant of the mode in which he educated his ſon. All that we know is, that young Monnier, from his earlieſt years, devoted himſelf to the ſtudy of aſtronomy; and that, when only ſixteen years of age, he made his firſt obſervation, viz. of the oppoſition of Saturn. At the age of twenty he was nominated a member of the Royal Academy of Sciences at Paris. In the year 1735 he accompanied Maupertuis in the celebrated expedition to Lapland, to meaſure a degree of latitude. In 1748 he went to Scotland with Lord Macclesfield, to obſerve the annular eclipſe of the ſun, which was moſt viſible in that country; and he was the firſt aſtronomer who had the pleaſure to meaſure the diameter of the moon on the diſk of the ſun.

Louis XV. it is well known, was extremely fond of aſtronomy, and greatly honoured its profeſſors: he loved and eſteemed Le Monnier. I have ſeen the king himſelf (ſays Lalande) come out of his cabinet, and look around for Le Monnier; and when his younger brother was preſented to him on his appointment to the office of firſt phyſician, his Majeſty was pleaſed to wiſh him the merit and reputation of his brother the aſtronomer. All the remarkable celeſtial phenomena were always obſerved by the king, in company with Le Monnier. Thus he obſerved with him, at his chateau of St Hubert, the two celebrated tranſits of Venus thro' the diſk of the ſun in the years 1761 and 1769; as appears from the Memoirs of the Royal Pariſian Academy of Sciences. It well deſerves to be here recorded in what manner the king behaved during theſe important obſervations, and how little he diſturbed his aſtronomers (the celebrated La Condamine being likewiſe permitted to obſerve the tranſit in his preſence) in this occupation; the proper time for which, if permitted to paſs by, could not be recalled. Le Monnier relates in his Diſſertation, that "his Majeſty perceiving that we judged the laſt contacts to be of the greateſt importance, a profound ſilence at that moment reigned around us." At the tranſit of Venus in 1769, the king allowed the Marquis de Chabert, an intelligent and expert naval officer, who was juſt returned from a literary voyage to the Levant, to aſſiſt at the obſervation. In a court like that of Louis XV. ſo ſcrupulouſly obſervant of etiquette, theſe will be allowed to have been moſt diſtinguiſhed marks of honour, and of royal favour and condeſcenſion.

In the year 1750, Le Monnier was ordered to draw a meridian at the royal Chateau of Bellevue, where the king frequently made obſervations. The monarch on this occaſion rewarded him with a preſent of 15,000 livres; but Le Monnier applied this ſum of money likewiſe in a manner that redounded to the honour of his munificent ſovereign and of his country, by procuring new and accurate inſtruments, with which he afterwards made his beſt and moſt remarkable obſervations. In 1742, the king gave him in Paris *Reu de la Poſte*, a beautiful free dwelling, where, till the breaking out of the revolution, he reſided, and purſued his aſtronomical labours, and where his inſtruments in part yet remain. Some of them the preſent French government has, at the inſtance of Lalande, purchaſed for the National Obſervatory. In 1751, the king preſented him with a block of marble, eight feet in height, ſix feet in breadth, and fifteen inches in thickneſs, to be uſed for fixing his mural quadrant of five feet. This marble wall, together with the inſtruments appended to it, turns on a large braſs ball and ſocket, by which the quadrant may be directed from ſouth to north; thus ſerving to rectify the large mural quadrant of eight feet, which is immoveably made faſt to a wall towards the ſouth.

With theſe quadrants Le Monnier obſerved, for the long period of forty years, the moon with unwearied perſeverance at all hours of the night. It is requiſite, to be a diligent aſtronomer, to be able to conceive to what numberleſs inconveniences the philoſopher is expoſed during an uninterrupted ſeries of lunar obſervations. As the moon during a revolution may paſs through the meridian at all hours of the day or night; the aſtronomer who, day after day, proſecutes ſuch obſervations, muſt be prepared at all, even the moſt inconvenient, hours, and ſacrifice to them his ſleep and all his enjoyments. How ſecluded from all the pleaſures of ſocial intercourſe, and how fatiguing ſuch a mode of life is, thoſe aſtronomers, indeed, know not who then only ſet their pendulum clocks in motion, when ſome of the eclipſes of the ſun, moon, or of the ſatellites of Jupiter, are to be viewed. At this time, and in the preſent ſtate of the ſcience, theſe are juſt the moſt inſignificant obſervations; and an able aſtronomer, well ſupplied with accurate inſtruments, may *every day*, if he take into his view the whole of his profeſſion, make more important and more neceſſary obſervations.

Le Monnier was Lalande's preceptor, and worthy of ſuch a ſcholar; and he promoted his ſtudies by his advice, and by every other means in his power. Le Monnier's penetrating mind, indeed, preſaged in young Lalande, then only ſixteen years old, what in the ſequel has been ſo ſplendidly confirmed. In his twentieth year, he became, on the recommendation of his preceptor, a member of the Royal Academy: and in 1752 he was propoſed by him as the fitteſt perſon to be ſent to Berlin, to make with La Caille's, who had been ſent to the Cape of Good Hope, correſpondent obſervations, for the purpoſe of determining the parallaxes of the moon, then but imperfectly known. Le Monnier lent his pupil for this expedition his mural quadrant of five feet. His zeal for aſtronomy knew no bounds. For this reaſon Lalande, in his *Notice des Travaux du C. Le Monnier*, ſays of himſelf: "*Je ſuis moi-meme le principal reſultat de ſon zele pour l'aſtronomie.*"

Le Monnier was naturally of a very irritable temper; as ardently as he loved his friends, as eaſily could he be offended; and his hatred was then implacable. Lalande, as he himſelf expreſſes it, had the misfortune to incur the diſpleaſure of his beloved preceptor; and he never after could regain his favour. But Lalande's gratitude and reſpect for him always continued undiminiſhed, and were on every occaſion with unremitting conſtancy publicly declared: patiently he endured from him undeſerved ill treatment; ſo much did he love and eſteem his inſtructor and maſter to the day of his death. "I have not ceaſed to exclaim (writes Lalande), as Diogenes exclaimed to his maſter Antiſthenes, You cannot find a ſtick ſtrong enough to drive me away from you!"

What a noble trait in the character of Lalande, who in 1797 wrote likewiſe an eulogium on Le Monnier in the ſtyle of a grateful pupil, penetrated with ſentiments of profound veneration and eſteem for his beloved maſter; but Le Monnier would not read it. This is not the place to give a circumſtantial account of this intricate quarrel; we ſhall only further remark, that Lalande was the warm friend and admirer of the no leſs eminent aſtronomer La Caille, whom Le Monnier mortally hated. An intimate friendſhip likewiſe ſubſiſted between Le Monnier and D'Alembert; but Lalande had no friendly intercourſe with the latter.

Among the ſcholars of Le Monnier may likewiſe be reckoned Henwart, the celebrated geometrician and profeſſor of mathematics at Utrecht; who, in a letter to Von Zach, aſtronomer to the Duke of Saxe Gotha, dated the 26th of May 1797, ſays, "Le Monnier is a penetrating and philoſophical aſtronomer: I learned much from him in Paris; though I lodged with the late De l'Iſle, where I frequently made obſervations in company with Meſſier. Le Monnier was the friend of D'Alembert; and conſequently an oppoſer of Lalande."

This great man, who had, for ſome years, ceaſed to exiſt either for the ſcience of aſtronomy, or for the comfort of his friends, died at Lizeaux, in the province of Normandy, in 1799, aged 84 years. He left behind him ſome valuable manuſcripts, and a number of good obſervations; with reſpect to which he had always been very whimſical, and of which in his latter years he never would publiſh any thing. He had by him a ſeries of lunar obſervations, and a multitude of obſervations of the ſtars, for a catalogue of the ſtars, which he had announced ſo early as the year 1741; among which was twice to be found the new planet Uranus: (See *Lalande's Aſtronomie, Tables*, p. 188, (A). The more he was requeſted to communicate his obſervations, the more obſtinate he became; he even threatened to deſtroy them. At the breaking out of the revolution, Lalande was greatly alarmed for the ſafety of theſe papers; he wiſhed to preſerve them from deſtruction, and made an attempt to get them into his poſſeſſion; but all his endeavours were in vain. He was only able to learn, that Le Monnier had hidden them under the roof of his houſe. Le Monnier having been firſt ſeized with a fit of the apoplexy ſo early as the 10th of November 1791, Lalande apprehended, leſt, if no one except himſelf ſhould know where he had hidden his papers, the infirm old man might perhaps have himſelf forgot it. He hopes, however, that La Grange, who married his ſecond daughter, may have ſome information concerning them. Le Monnier left behind him no ſon.

MONOMIAL, in algebra, is a ſimple or ſingle nomial, conſiſting of only one term; as a or ax, or a^3bx^3, &c.

MONOTRIGLYPH, a term in architecture, denoting the ſpace of one triglyph between two pilaſters, or two columns.

MONSELEMINES, are a people which inhabit that part of BILEDULGERID (ſee *Encycl.*) that borders on the territories of the Emperor of Morocco. They are a mixed race, being deſcended from the ancient Arabs and fugitive Moors; and they occupy a ſpace of land, of which the limits are indicated by lofty columns placed at intervals towards the deſart. Their territory extends from about 30 leagues beyond Cape Non, to the diſtance of 20 leagues from St Croix or Agader. Though of different qualities, it is, for the moſt part, very fertile, and produces the neceſſaries of life with little cultivation. The plains are watered by an infinite number of ſtreams, and abound with palm, date, fig, and almond trees. The gardens produce excellent grapes, which are dried by the Arabs, and converted into brandy by the Jews. Great quantities of oil, wax, and tobacco, appear in the public markets.

More induſtrious and more laborious than their neighbours, the Monſelemine nation cultivates the earth. The chiefs of families chooſe the ground moſt fit for cultivation. Its ſurface is turned ſlightly over with a kind of hoe, and then the ſeed is ſown upon it: the field is ſurrounded with buſhes, to mark the ſpot, and to preſerve it from the cattle of the wandering Arabs. When the crop is ripe, which is generally at the end of Auguſt, three months after the ſowing of the ſeed, it is cut about ſix inches from the ear; and formed into little bundles; during which time every one labours without intermiſſion from morning to night. The corn is brought before the tent, thraſhed, winnowed, and placed in the magazines. When the harveſt is over, they ſet fire to the long ſtubble, and abandon the field for two or three years. Their magazines are large holes in the earth, formed like the fruſtum of a cone, the inſides of which are hardened by burning wood in them, before the half winnowed corn be depoſited. When filled with corn, they are covered with planks placed cloſe to each other; over which a layer of earth is laid level with the ſoil, to prevent it from being diſcovered by enemies. In theſe magazines every one ſhares in proportion to the number of men he employed in the common labour.

The inhabitants of the plains remain by the cultivated fields in ſeed time, and return at the time of harveſt. During the intervals they wander in all directions with their cattle, taking only neceſſaries along with them, and having recourſe to the magazines when they require

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(A) Such is the French and German account of his diſcovery of this planet; but our readers have been very inattentive, if they have not perceived, in various articles of this Work, complete proofs of the plagiariſm of our neighbours on the Continent, from the celebrated philoſophers and divines of England. As it is extremely probable that, half a century hence, a claim may be put in for Le Monnier's diſcovery of the Georgium Sidus (*Uranus*), ſimilar to that which in 1757 the editor of Abbé St Real's works put in for that Abbé being the author of Leſlie's *Short Method with the Deiſts* (ſee LESLIE in this *Suppl.*), we think it our duty to declare, that in 1800 there was no evidence whatever on which to found that claim, and that the diſcovery was then univerſally allowed to have been made by Herſchel.

quire a ſupply. The more opulent people, and the artizans who are engaged in ſedentary occupations, dwell in towns, which are all ſituated upon the declivity of hills. Their houſes are built of ſtone and earth, according to the Mooriſh conſtruction, low and covered with ſloping terraces; yet they are ſo much injured by the heavy rains which prevail for three months of the year, as to be rendered uninhabitable in 15 or 20 years. Thoſe who reſide in towns are generally weavers, ſhoemakers, goldſmiths, potters, &c and have no cattle; but the more opulent perſons have flocks and herds of cows, horſes, camels, ſheep, goats, beſides poultry, which are kept by their ſlaves at a diſtance from the towns. In the towns they take two meals a day; one at ten o'clock, and the other at the ſetting of the ſun, though the inhabitants of the country only eat in the evening. In the towns they ſleep in mats upon the floors of their apartments, and make uſe of linen; but the inhabitants of the country ſleep upon terraces in the open air. The paſtoral families of the country practiſe hoſpitality like thoſe of the deſart, and make the traveller pay nothing for his entertainment. In the towns this practice is impoſſible, as the concourſe of ſtrangers, eſpecially on market-days, would ſoon impoveriſh the inhabitants. In this manner hoſpitality is always extinguiſhed among a trading and commercial people. It is only where the ſuperfluity of commodities runs neceſſarily to waſte, that it is ever practiſed in a great extent; but where every commodity can find a market, every kind of property acquires a definite value, and will be preſerved with the ſame care as money.

By M. Saugnier the government of the Monſelemines is ſaid to be republican; but he writes inconſiſtently about it In one place, he ſays that they chooſe their chiefs annually; in another, that in the time of war they chooſe from the natives or fugitive Moors indiſcriminately, chiefs, whoſe authority laſts no longer than the campaign, during which it is abſolute; and he afterwards repreſents their government as a kind of theocracy, during war as well as peace. But we muſt follow him in his detail, as it has been well arranged in a late anonymous publication, entitled, *An Hiſtorical Sketch of Diſcoveries in Africa.*

At the end of each campaign, he ſays the chief gives an account of his actions to the aſſembled aged men, and is rewarded or puniſhed according to his conduct; after which his ſucceſſor is appointed, and he ſerves in the army he commanded as an undiſtinguiſhed individual. The country is populous, and would be ſtill more ſo, were it not for the continual wars which its inhabitants are obliged to ſupport againſt the Emperor of Morocco. The liberty they enjoy imparts energy and courage to their character, and renders their arms invincible to the Moors. They conſider it as the moſt invaluable poſſeſſion, and defend it to the laſt extremity. The nature of the country, ſurrounded on every ſide by ſteep and arid mountains, contributes to fruſtrate the efforts of their enemies. The Monſelemine, richer than the ſubject of Morocco, is always well clothed and armed. He pays no tribute, enjoys the fruit of his labour and commerce, and, as no contributions are requiſite for the charges of the ſtate, whatever he acquires is his own. The fugitive Moors are never armed, except when they go to battle; but the natives go continually armed, whether they reſide in the country, reſort to the markets, attend the aſſemblies of the nation, or pay viſits.

As the Monſelemine territory is the retreat of the rich Moors, who wiſh to fly from the tyranny of the Emperor of Morocco, they are too well acquainted with the Mooriſh cuſtoms to be ſurpriſed by that prince. No ſooner does a Mooriſh army take the field, than the inhabitants of the country cantons mount their horſes, and occupy the paſſes of the mountains; while the women and ſlaves, eſcorted by a ſufficient number of warriors, retire to the interior parts of the country, or, if they be hard preſſed, to the deſart. Among the paſtoral tribes there are many that addict themſelves entirely to arms, and ſerve as cavalry in the time of war. During peace they eſcort caravans, or exerciſe themſelves in military evolutions, and the management of their horſes. Being almoſt always on horſeback, and wearing no boots, they have a callous lump on that part of the leg that comes in contact with the iron of the ſtirrup. Their horſes, which they break in an admirable manner, are the beſt in the world: as they are treated with great care by their maſters, they know them, and are obedient to their voice, and will admit no ſtranger to mount them.

The Monſelemines derive their origin and name from Moſeilama, a contemporary of Mahomet; and, in their love of liberty, as well as in many of their cuſtoms, reſemble the Arabs of remoter times. They reſpect the prophet like other Mahometans; but neither believe that he was infallible, nor that his deſcendants are all inſpired by God, nor that their will ſhould be a law, nor that ſuch faith is neceſſary in order to be a good Mahometan. Their prieſts are reſpected, and in old age generally become the civil judges of the nation; but the influence of the high prieſt is almoſt deſpotic. Though he has no troops, he may command the nation; and war and peace depend upon his will. Though he has no property, every thing is at his diſpoſal: he requires nothing from any one, and yet all are inclined to give. He adminiſters juſtice according to the opinion of his counſel, without pretending to be inſpired by the prophet.

On Friday the Monſelemines aſſemble in their moſques to pray: this is likewiſe the day of their principal market, when their merchandize is expoſed to ſale in the public ſquares, where the old men judge without appeal, when diſputes ariſe. Different from their neighbours of Morocco and Sahara, the Monſelemines never attempt to make proſelytes. Their Chriſtian ſlaves are treated with humanity; but they owe this to the avarice of their maſters. Theſe deteſt Chriſtians, but they love money, and are afraid leſt ſickneſs or death ſhould deprive them of the ranſom of the ſlave, or of the advantage of his labour.' Among the inhabitants of the deſart, a Chriſtian, that adopts the religion of Mahomet, is admitted as a citizen and member of the family, and is preſented with cattle to form an eſtabliſhment. The Monſelemines pay more attention to the value of their property than the ſituation of the infidel. A Chriſtian who enters a moſque at Morocco is put to death, or forced to aſſume the turban. The Monſelemines would turn him civilly out, and content themſeles with impoſing the higheſt poſſible fine. Among the Moors, a Chriſtian diſcovered in an intrigue with a woman of that nation ſuffers death, or ſubmits to converſion; but the Monſelemines prefer money to religion. From them the Chriſtian has nothing to fear: the woman alone is puniſhed, being put into a ſack, and thrown into the ſea. If a Chriſtian ſlave among the neighbouring nations defends himſelf againſt his maſter, he is puniſhed with death; but money ſaves him among the Monſelemines; he would at moſt receive a ſlight correction.

The Jews are allowed the free exerciſe of their religion among the Monſelemines, but are treated with the ſame indignity as among other Mahometan tribes. A Jew is not permitted to carry arms; and if he ſhould make uſe of them againſt an Arab, he would be puniſhed with death, and probably involve his family in his fate. The Jews inhabit the towns only, where they follow trade and various arts, but are not allowed to cultivate the earth.

Polygamy is permitted, as in other Mahometan countries; but the ſituation of the women is more reſpectable, and they are not ſo much ſecluded as among the Moors. They mingle more in ſociety, walk at large, and viſit their friends; neither are their apartments ſo inviolable. Among the Monſelemines, that degrading picture of humanity is never ſeen which ſometimes occurs in Morocco, a woman drawing the plough with an aſs, a mule, or ſome other beaſt of burden. More happy than the women of the Sahara, and treated with greater attention by their huſbands, they are more humane in their diſpoſitions. Like other Arab women, they ſtain the edges of their eyelids black with henna, and paint their faces red and yellow. Their children are brought up with great care, and are not obliged to exhibit proofs of their courage before they can be conſidered as men, as is the cuſtom in the deſart. Avarice is the principal defect in the character of the Monſelemines. They hoard their money with the utmoſt care, bury it in the earth, and in many caſes die without diſcovering their ſecret even to their children. Miſers, ſays M. Saugnier, ſhould go to that country, where they would learn means of economy; which would ſhew them, that, in compariſon with the Monſelemines, they are themſelves perfect prodigals.

The medicinal applications of the Monſelemines, which differ not from thoſe of the MONGEARTS and other inhabitants of the deſart, are extremely ſimple, but appear ſufficiently complex from the mummery of the prieſts, who are the depoſitories of their medical ſcience. Fleſh wounds are cauteriſed with a hot iron, and then covered with herbs dipped in turtles oil and tar. In headachs, a compreſs is applied with ſuch violence that the blood ſtarts from the forehead. In internal diſeaſes, the general remedies are regimen, reſt, and a few maxims of the Koran myſteriouſly applied to the affected parts.

MONTEREY BAY, in North California, was viſited in 1786 by La Perouſe, who places it in 36° 58′ 41″ N. Lat. and 124° 40′ W. Long. from Paris. It is formed by New-year Point to the north, and by that of Cyprus to the ſouth; has an opening of eight leagues in this direction, and nearly ſix of depth to the eaſtward, where the land is ſandy and low. The ſea breaks there as far as the foot of the ſandy downs with which the coaſt is ſurrounded, with a roaring which may be heard more than a league off. The lands north and ſouth of this bay are high, and covered with trees. Thoſe ſhips which are deſirous of touching there ought to follow the ſouth coaſt, and after having doubled the Point of Pines, which ſtretches to the northward, they get ſight of the preſidency, and may come to an anchor in ten fathoms within it, and a little within the land of this point, which ſhelters from the winds from the offing. The Spaniſh ſhips, which propoſe to make a long ſtay at Monterey, are accuſtomed to bring up within one or two cable's lengths of the land, in ſix fathoms, and make faſt to an anchor, which they bury in the ſand of the beach; they have then nothing to fear from the ſoutherly winds, which are ſometimes very ſtrong; but, as they blow from the coaſt, do not expoſe them to any danger. The two French frigates, which our author commanded, found bottom over the whole bay, and anchored four leagues from the land, in 60 fathoms, ſoft muddy ground; but there is a very heavy ſea, and it is only an anchorage fit for a few hours, in waiting for day, or the clearing up of the fog. At full and change of the moon it is high water at half paſt one o'clock: the tide riſes ſeven feet; and as this bay is very open, the current in it is nearly imperceptible. It abounds with whales; a genus of fiſhes, of which our *ſcientific* voyagers knew ſo little, that they were ſurpriſed at their ſpouting water!

The coaſts of Monterey Bey are almoſt continually enveloped in fogs, which cauſe great difficulty in the approach to them. But, for this circumſtance, there would be few more eaſy to land upon; there is not any rock concealed under water that extends a cable's length from the ſhore; and if the fog be too thick, there is the reſource of coming to an anchor, and there waiting for a clear, which will enable you to get a good ſight of the Spaniſh ſettlement, ſituated in the angle formed by the ſouth and eaſt coaſt. The ſea was covered with pelicans. Theſe birds, it ſeems, never go farther than five or ſix leagues from the land; and navigators, who ſhall hereafter meet with them during a fog, may reſt aſſured that they are within that diſtance of it.

A lieutenant-colonel, whoſe reſidence is at Monterey, is governor of the Californias: the extent of his government is more than 800 leagues in circumference, but his real ſubjects conſiſt only of 282 cavalry, whoſe duty it is to garriſon five ſmall forts, and to furniſh detachments of four or five men to each of the 25 miſſions, or pariſhes, eſtabliſhed in old and new California. So ſmall are the means which are adequate to the reſtraining about 50,000 wandering Indians in this vaſt part of America, among whom, nearly 10,000 have embraced Chriſtianity. Theſe Indians are, in general, ſmall and weak (A), and diſcover none of that love of liberty and independence which characteriſes the northern nations, of whoſe arts and induſtry they are alſo deſtitute. Their colour very nearly approaches that of the negroes whoſe hair is not woolly; the hair of theſe people is ſtrong, and of great length; they cut it four or five inches from the roots. Several among them have a beard; others, according to the miſſionary fathers, have never had any; and this is a queſtion which is even undecided

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(A) The chief ſurgeon of the expedition ſays they are *ſtrong*, but ſtupid.

decided in the country. The governor, who had travelled a great way into the interior of theſe lands, and who had paſſed 15 years of his life among the ſavages, aſſured our author, that thoſe who had no beards had plucked them up with bivalve ſhells, that ſerved them as pincers: the preſident of the miſſions, who had reſided an equal length of time in California, maintained the contrary;—it was difficult, therefore, for travellers to decide between them." The difficulty, ſurely, was not great. By their own account, the governor had travelled much farther into the country than the miſſionary; and his report being confirmed by the evidence of their own ſenſes, was intitled to unlimited credit.

Theſe Indians are extremely ſkilful in drawing the bow; they killed, in the preſence of the French, the ſmalleſt birds: it is true, they diſplay an inexpreſſible patience in approaching them; they conceal themſelves, and, as it were, glide along near to the game, ſeldom ſhooting till within 15 paces. Their induſtry in hunting the larger animals is ſtill more admirable. Perouſe ſaw an Indian, with a ſtag's head fixed upon his own, walk on all-fours, as if he were browſing the graſs; and he played this pantomime to ſuch perfection, that all the French hunters would have fired at him at 30 paces, had they not been prevented. In this manner they approach herds of ſtags within a very ſmall diſtance, and kill them with a flight of arrows.

Before the Spaniſh ſettlements, the Indians of California cultivated nothing but maize, and almoſt entirely lived by fiſhing and hunting. There is not any country in the world which more abounds in fiſh and game of every deſcription: hares, rabbits, and ſtags are very common there; ſeals and otters are alſo found there in prodigious numbers; but to the northward, and during the winter, they kill a very great number of bears, foxes, wolves, and wild cats. The thickets and plains abound with ſmall grey tufted partridges, which, like thoſe in Europe, live in ſociety, but in large companies of three or four hundred; they are fat, and extremely well flavoured. The trees ſerve as habitations to the moſt delightful birds; and the ornithologiſts of the voyage ſtuffed a great variety of ſparrows, titmice, ſpeckled wood-peckers, and tropic birds. Among the birds of prey are found the white headed eagle, the great and ſmall falcon, the goſs hawk, the ſparrow hawk, the black vulture, the large owl, and the raven. On the ponds and ſea-ſhore are ſeen the wild duck, the grey and white pelican with yellow tufts, different ſpecies of gulls, cormorants, curlews, ring-plovers, ſmall ſea water hens, and herons; together with the bee-eater, which, according to moſt ornithologiſts, is peculiar to the old continent.

The country about Monterey Bay is inexpreſſibly fertile. The crops of maize, barley, corn, and peaſe, cannot be equalled but by thoſe of Chili; our European cultivators can have no conception of a ſimilar fertility; the medium produce of corn is from ſeventy to eighty for one; the extremes ſixty and a hundred. Fruit trees are ſtill very rare there, but the climate is extremely ſuitable to them: it differs a little from that of the ſouthern French provinces. The foreſt trees are, the ſtone-pine, cypreſs, evergreen oak, and occidental plane tree. There is no underwood; and a verdant carpet, over which it is very agreeable to walk, covers the ground. There are alſo vaſt ſavannahs, abounding with all ſorts of game.

Perouſe writes with great reſpect of the wiſe and pious conduct of the Spaniſh miſſionaries at Monterey, who ſo faithfully fulfil the purpoſe of their inſtitution. Totally unlike the monks at CONCEPTION in Chili (ſee that article in this *Suppl.*), they have left the lazy life of a cloiſter, to give themſelves up to cares, fatigues, and ſolicitudes of every kind. They invited the officers of the frigates to dine with them at their monaſtery, contiguous to which ſtands the Indian village, conſiſting of about 50 cabins, which ſerve as dwelling-places to 740 perſons of both ſexes, compriſing their children, which compoſe the miſſion of Saint Charles, or of Monterey. Theſe cabins are the moſt miſerable that are to be met with among any people; they are round, ſix feet in diameter, by four in height; ſome ſtakes, of the ſize of an arm, fixed in the earth, and which approach each other in an arch at the top, compoſe the timber work of it; eight or ten bundles of ſtraw, very ill arranged over theſe ſtakes, defend the inhabitants, well or ill, from the rain and wind; and more than half of this cabin remains open when the weather is fine; their only precaution is to have each of them two or three bundles of ſtraw at hand by way of reſerve.

All the exhortations of the miſſionaries have never been able to procure a change of this general architecture of the two Californias. The Indians ſay, that they like plenty of air; that it is convenient to ſet fire to their houſes when they are devoured in them by too great a quantity of fleas; and that they can build another in leſs than two hours. The independent Indians, who as hunters ſo frequently change their places of abode, have a ſtronger motive.

The monks gave the moſt complete information reſpecting the government of this ſpecies of religious community; for no other name can be given to the legiſlation they have eſtabliſhed. They are ſuperiors both in ſpiritual and temporal affairs: the products of the land are entirely entruſted to their adminiſtration. There are ſeven hours allotted to labour in the day, two hours to prayers, and four or five on Sundays and feſtivals, which are altogether dedicated to reſt and divine worſhip. Corporal puniſhments are inflicted on the Indians of both ſexes who neglect pious exerciſes; and ſeveral ſins, the puniſhment of which in Europe is reſerved only to Divine Juſtice, are puniſhed with chains or the ſtocks.

The Indians, as well as the miſſionaries, riſe with the ſun, and go to prayers and maſs, which laſt an hour; and during this time there is cooked in the middle of the ſquare, in three large kettles, barley meal, the grain of which has been roaſted previous to being ground; this ſpecies of boiled food, which the Indians call *atole*, and of which they are very fond, is ſeaſoned neither with ſalt nor butter, and to us would prove a very inſipid meſs. Every cabin ſends to take the portion for all its inhabitants in a veſſel made of bark: there is not the leaſt confuſion or diſorder; and when the coppers are empty, they diſtribute that which ſticks to the bottom to the children who have beſt retained their leſſons of catechiſm. This meal continues three quarters of an hour, after which they all return to their labours; ſome go to plough the earth with oxen, others to dig the garden; in a word, every one is employed in different domeſtic occupations, and always under the ſuperintendance of one or two of the religious.

The women are charged with little elſe but the care of their houſewifery, their children, and roaſting and grinding the ſeveral grains: this laſt operation is very long and laborious, becauſe they have no other means of doing it but by cruſhing the grain in pieces with a cylinder upon a ſtone. M. de Langle, being a witneſs of this operation, made the miſſionaries a preſent of his mill; and a greater ſervice could not have been rendered them, as by theſe means four women would in a day perform the work of a hundred, and time enough will remain to ſpin the wool of their ſheep, and to manufacture coarſe ſtuffs.

At noon the dinner was announced by the bell; the Indians quitted their work, and ſent to fetch their rations in the ſame veſſels as at breakfaſt: but this ſecond meſs was thicker than the firſt; there was mixed in it corn and maize, and peaſe and beans; the Indians name it *pouſſole*. They return again to their labour from two o'clock till four or five; afterwards they attend evening prayers, which continue near an hour, and are followed by a new ration of *atole* like that at breakfaſt. Theſe three diſtributions are ſufficient for the ſubſiſtence of the far greater number of Indians; and this very economical ſoup might perhaps be very profitably adopted in our years of ſcarcity; ſome ſeaſoning would certainly be neceſſary to be added to it, their whole knowledge of cookery conſiſting in being able to roaſt the grain before it is reduced into meal. As the Indian women have no veſſels of earth or metal for this operation, they perform it in large baſkets made of bark, over a little lighted charcoal; they turn theſe veſſels with ſo much rapidity and addreſs, that they effect the ſwelling and burſting of the grain without burning the baſket, though it is made of very combuſtible materials.

The corn is diſtributed to them every morning; and the ſmalleſt diſhoneſty, when they give it out, is puniſhed by whipping: but it is very ſeldom, indeed, they are expoſed to it. Theſe puniſhments are adjudged by Indian magiſtrates, called *caciques;* there are in every miſſion three of them, choſen by the people from amongſt thoſe whom the miſſionaries have not excluded: but theſe caciques are like the governors of a plantation, paſſive beings, blind executors of the will of their ſuperiors; and their principal functions conſiſt in ſerving as beadles in the church, and their maintaining order and an air of contemplation. The women are never whipped in public, but in an incloſed and ſomewhat diſtant place, leſt perhaps their cries might inſpire too lively a compaſſion, which might ſtimulate the men to revolt; theſe laſt, on the contrary, are expoſed to the view of all their fellow-citizens, that their puniſhment may ſerve as an example. In general they aſk pardon; in which caſe the executioner leſſens the force of his laſhes, but the number of them is never receded from.

The rewards are particular ſmall diſtributions of grain, of which they make little thin cakes, baked on burning coals: and on the great feſtivals the ration is in beef; many of them eat it raw, eſpecially the fat, which they eſteem equal to the beſt butter or cheeſe. They ſkin all animals with the greateſt addreſs; and when they are fat, they make, like the ravens, a croaking of pleaſure, devouring, at the ſame time, the moſt delicate parts with their eyes.

They are frequently permitted to hunt and fiſh on their own account; and on their return they generally make the miſſionaries ſome preſent in game and fiſh; but they always proportion the quantity to what is abſolutely neceſſary for them, always taking care to increaſe it if they hear of any new gueſts who are on a viſit to their ſuperiors. The women rear fowls about their cabins, the eggs of which they give their children. Theſe fowls are the property of the Indians, as well as their clothes, and other little articles of houſehold furniture, and thoſe neceſſary for the chace. There is no inſtance of their having robbed each other, though their faſtenings to the doors conſiſt only of a ſimple bundle of ſtraw, which they place acroſs the entrance when all the inhabitants are abſent.

The men in the miſſions have ſacrificed much more to Chriſtianity than the women; becauſe they were accuſtomed to polygamy, and were even in the cuſtom of eſpouſing all the ſiſters of a family. The women, on the other hand, have acquired the advantage of excluſively receiving the careſſes of one man only. With this, however, it would appear that they are not ſatisfied; for the religious have found it neceſſary to conſtitute themſelves the guardians of female virtue. At an hour after ſupper, they have the care of ſhutting up, under lock and key, all thoſe whoſe huſbands are abſent, as well as the young girls above nine years of age; and during the day they are entruſted to the ſuperintendance of the matrons. So many precautions are ſtill inſufficient; for our voyagers ſaw men in the ſtocks, and women in irons, for having deceived the vigilance of theſe female arguſſes, who had not been ſufficiently ſharp-ſighted.

The converted Indians have preſerved all the ancient uſages which their new religion does not prohibit; the ſame cabins, the ſame games, the ſame dreſſes: that of the richeſt conſiſts of an otter's ſkin cloak, which covers their loins, and deſcends below their groin; the moſt lazy have only a ſimple piece of linen cloth, with which they are furniſhed by the miſſion, for the purpoſe of hiding their nakedneſs; and a ſmall cloak of rabbit's ſkin covers their ſhoulders, which is faſtened with a pack-thread under the chin; the head and the reſt of the body is abſolutely naked; ſome of them, however, have hats of ſtraw, very neatly matted. The womens dreſs is a cloak of deer ſkin, ill tanned; thoſe of the miſſions have a cuſtom of making a ſmall boddice, with ſleeves, of them: it is their only apparel, with a ſmall apron of ruſhes, and a petticoat of ſtag's ſkin, which covers their loins, and deſcends to the middle of the leg. The young girls, under nine years of age, have merely a ſimple girdle; and the children of the other ſex are quite naked.

The independent ſavages are very frequently at war; but the fear of the Spaniards makes them reſpect their miſſions; and this, perhaps, is not one of the leaſt cauſes of the augmentation of the Chriſtian villages. Their arms are the bow, and arrow pointed with a flint very ſkilfully worked: theſe bows are made of wood, and ſtrung with the ſinews of an ox. Our author was aſſured, that they neither eat their priſoners, nor their enemies killed in battle; that, nevertheleſs, when they had vanquiſhed, and put to death on the field of battle, chiefs, or very courageous men, they have eaten ſome pieces of them, leſs as a ſign of hatred or revenge, than as a homage which they paid to their valour, and in the full perſuaſion that this food would be likely to increaſe their own courage. They ſcalp the vanquiſhed as in Canada, and pluck out their eyes; which they have the art of preſerving free from corruption, and which they carefully keep as precious ſigns of their victory. Their cuſtom is to burn their dead, and to depoſit their aſhes in morais.

MOORS, in common language, are the natives of Morocco, of whom an account is given under that title in the *Encyclopædia;* but there is another people, a mixed race, called alſo Moors, who lead a wandering and paſtoral life in the habitable parts of the Great Deſert, and in the countries adjacent to it. Of the origin of theſe Mooriſh tribes, as diſtinguiſhed from the inhabitants of Barbary, nothing farther ſeems to be known than what is related by John Leo the African; whoſe account may be abridged as follows:

Before the Arabian conqueſt, about the middle of the ſeventh century, all the inhabitants of Africa, whether they were deſcended from Numidians, Phœnicians, Carthaginians, Romans, Vandals, or Goths, were comprehended under the general name of *Mauri* or Moors. All theſe nations were converted to the religion of Mahomet, during the Arabian empire under the Kaliphs. About this time many of the Numidian tribes, who led a wandering life in the deſert, and ſupported themſelves upon the produce of their cattle, retired ſouthward acroſs the Great Deſert, to avoid the fury of the Arabians; and by one of thoſe tribes, ſays Leo (that of Zanhaga), were diſcovered, and conquered, the Negro nations on the Niger. By the Niger, is here undoubtedly meant the river of Senegal which in the Mandingo language is called *Baſing*, or the Black River.

To what extent theſe people are now ſpread over the African continent, it is difficult to aſcertain. There is reaſon to believe, that their dominion ſtretches from weſt to eaſt, in a narrow line or belt, from the mouth of the Senegal (on the northern ſide of that river) to the confines of Abyſſinia. Mr Park deſcribes them as reſembling, in complexion, the Mulattoes of the Weſt Indies, and as having cruelty and low cunning pictured in their countenances. "From the ſtaring wildneſs in their eyes (ſays he), a ſtranger would immediately ſet them down as a nation of lunatics. The treachery and malevolence of their character are manifeſted in their plundering excurſions againſt the Negro villages. Oftentimes, without the ſmalleſt provocation, and ſometimes under the faireſt profeſſions of friendſhip, they will ſuddenly ſeize upon the Negroes cattle, and even on the inhabitants themſelves. The Negroes very ſeldom retaliate. The enterpriſing boldneſs of the Moors, their knowledge of the country, and, above all, the ſuperior fleetneſs of their horſes, make them ſuch formidable enemies, that the petty Negro ſtates, which border upon the deſert, are in continual alarm while the Mooriſh tribes are in the vicinity, and are too much awed to think of reſiſtance.

"Like the roving Arabs, the Moors frequently remove from one place to another, according to the ſeaſon of the year, or the convenience of paſturage. In the month of February, when the heat of the ſun ſcorches up every ſort of vegetation in the deſert, they ſtrike their tents, and approach the Negro country to the ſouth; where they reſide until the rains commence, in the month of July. At this time, having purchaſed corn, and other neceſſaries from the Negroes, in exchange for ſalt, they again depart to the northward, and continue in the deſert until the rains are over, and that part of the country becomes burnt up and barren.

"This wandering and reſtleſs way of life, while it inures them to hardſhips, ſtrengthens, at the ſame time, the bonds of their little ſociety, and creates in them an averſion towards ſtrangers, which is almoſt inſurmountable. Cut off from all intercourſe with civilized nations, and boaſting an advantage over the Negroes, by poſſeſſing, though in a very limited degree, the knowledge of letters, they are at once the vaineſt and proudeſt, and perhaps the moſt bigotted, ferocious, and intolerant, of all the nations on the earth; combining in their character the blind ſuperſtition of the Negro, with the ſavage cruelty and treachery of the Arab." But for them Mr Park would have accompliſhed the utmoſt object of his miſſion, and have reached Tombuctoo, and even Houſſa, with no other danger than what ariſes neceſſarily from the climate, from wild beaſts, and from the poor accommodation afforded in the huts of the hoſpitable Negroes. The wandering Moors, however, have all been taught to regard the Chriſtian name with inconceivable abhorrence; and to conſider it nearly as lawful to murder a European as it would be to kill a dog. It is, therefore, much leſs ſurpriſing that our traveller did not proceed farther along the banks of the Niger, than that he eſcaped the ſnares of ſo relentleſs a people.

MORINDA, is a plant, of which a very meagre deſcription has been given in the *Encyclopædia*, though it is of much importance in oriental commerce. It is cultivated to a great extent in the province of *Malwa* in the Eaſt Indies, where it furniſhes a valuable dye-ſtuff; and is thus deſcribed by William Hunter, Eſq; in the fourth volume of the Aſiatic Reſearches:

"It is a tree of a middling ſize; the *root* branchy; the *trunk* columnar, erect, covered with a ſcabrous bark. *Branches*, from the upper part of the trunk, ſcattered; of the ſtructure of the trunk. *Leaves* (ſeminal) oval, obtuſe, entire (mature), oppoſite, decuſſated, ovate, pointed at both ends, ſmooth, with very ſhort petioles. *Stipules*, lanced, very ſmall, withering. *Peduncles*, from the axils of the leaves, ſolitary, bearing an aggregate flower. *Calyx*, common receptacle roundiſh, collecting the ſeſſile flowers into an irregular head. *Perianth*, moſt entire, ſcarce obſervable above. *Coral*, one-petalled, funnel-form. *Tube*, cylindric: *Border*, five cleft; the *diviſions* lanced. *Stamen: Filaments*, five, thread-form, ariſing from the tube, and adhering to it through two thirds of their length, a little ſhorter than the tube. *Anthers*, linear, erect. *Piſtil. Germ*, beneath, four-celled, containing the rudiments of four ſeeds. *Style*, thread form, longer than the ſtamens. *Stigma*, two-cleft, thickiſh. *Pericarp*, common, irregular, divided on the ſurface into irregular angular ſpaces; compoſed of berries, pyramidal, compreſſed on all ſides by the adjacent ones, and concreted with them; lopped; containing towards the baſe a fleſhy pulp. *Seeds*, in each berry four; towards the point oblong, externally convex, internally angular."

The ſpecies here deſcribed is the *morinda arborea pedunculis ſolitariis* of Linnæus. It grows beſt in a black rich ſoil, free from ſtones, in ſituations moderately moiſt, not too high, yet ſufficiently elevated to prevent the rain water from ſtagnating, and where a ſupply of water can be had for the dry months. As the colouring matter, for which alone it is valuable, reſides chiefly in the bark of the root, the ſmall twigs, which contain little wood, bear a higher price than the larger pieces. The natives employ it in dyeing a pale red, or clay colour; which Mr Hunter ſays is more valuable for its durability than for its beauty. They likewiſe uſe it in dyeing a dark purple or chocolate colour: but for the proceſs, in both caſes, we muſt refer to the original memoir.

MORION, in botany, a name given by the ancients to a kind of nightſhade. See SOLANUM, *Encycl.*

MORION, in ancient mineralogy, a name given to one of the ſemipellucid gems, more commonly called *pramnion*. It is a ſtone appearing externally of a fine deep black; but when held up againſt a candle, or againſt the ſun-beams, it gives a very beautiful red in different degrees.

MOSHAIRA, or MOSHAHEREN, penſion or allowance in Bengal.

MOSS, the name given in Scotland, and we believe alſo in ſome parts of England, to what is more properly called a *moraſs*, a *fen*, or a *bog*. On the formation of theſe moſſes ſome conjectures have been hazarded in the *Encyclopædia*, where the reader will likewiſe find a copious account of the method which has for many years been ſucceſsfully employed to convert the MOSS OF KINCARDINE into an arable ſoil, or rather to remove the ſubſtance called *moſs* or *peat* from the rich ſoil which is found below it. A method, however, has been invented by Mr John Smith of Swindrig-muir, in the ſhire of Ayr, for *actually* converting the ſubſtance called moſs into a vegetable mould, which has been found by experience to carry rich crops of corn, hay, potatoes, &c. Of this gentleman's practice we have the following account in a ſmall pamphlet publiſhed in Edinburgh, 1798, by Fairbairn and Dickſon.

"The firſt thing to be done is to mark off, and cut out, proper main or maſter drains, in order to carry off the ſuperfluous water, taking care to preſerve the greateſt poſſible level; which drains are ſo conſtructed as to divide the field into incloſures from ſix to ten Scotch acres. If the moſs hangs or declines, the incloſures may be of any dimenſion whatever. The dimenſions of theſe drains when firſt made are eight feet wide, by four and a half feet deep, declining to two and a half feet at bottom, and coſt at the rate of one ſhilling per fall of eighteen and a half feet, running meaſure. The ridges are then to be marked off regularly, ſix or ſeven yards broad, formed with the ſpade in the manner following.

"In the centre of each ridge, a ſpace of about 20 inches is allowed to remain untouched, on each ſide of which a furrow is opened, and turned upon the untouched ſpace, ſo as completely to cover it (like what is called the feering of a gathered ridge). Thus begun, the work is continued, by cutting with the ſpade, in width about 12 inches, and turning it over to appearance as if done with a plough, until you come to the diviſion furrow, which ſhould be two feet wide, cut out and thrown upon the ſides of the ridges. The depth of the diviſion furrow is to be regulated by circumſtances, according as the moſs is wet or dry, but ſo as to anſwer the purpoſe of as it were bleeding the moſs, and conducting the water to the main drains.

"It may be here obſerved, that the ſucceſs of the aftercrops depends very much upon a proper formation of the ridges. They muſt not be made too high in the middle, for there they will be too dry like a peat, upon which the lime cannot act, and near the furrows they will be too wet, which is equally prejudicial; they ſhould therefore be conſtructed with a gentle declivity to the furrows, ſo as the rain which falls may rather filtrate through the ridge to the furrows than run quickly off the ſurface.

"The next operation is to top-dreſs the ridges with lime, at the rate of from four to eight chalders per acre. Five Wincheſter buſhels make a boll, and eight bolls a chalder of ſhell lime, producing fixteen bolls powdered lime. The quicker the lime is put on after being ſlacked the better.

"The proper ſeaſon to prepare the moſs for a firſt crop is early the preceding ſummer; in that caſe the lime, aided by the heat, the after rains, and the winter froſts, makes conſiderable progreſs in the proceſs of putrefaction, conſequently forms a mould to receive the ſeed.

"Though oats have ſometimes ſucceeded as a firſt crop, potatoes have been found greatly preferable. The method of planting them is ſimple, and attended with little expence. The moſs, prepared by ridges, and limed as before deſcribed, beds for the potatoes are, in the ſpring, marked off, acroſs the ridges, five or ſix feet broad, with intermediate ſpaces of about two feet, as furrows or trenches. The beds are covered over with a thin ſtratum of dung, about eighteen ſingle-horſe carts to an acre, the cuttings of the potatoes are laid or placed upon the beds, about ten or twelve inches aſunder, and the whole covered over with a thin ſtratum of moſs from the intermediate trenches, which is followed by another covering from the trenches when the potatoe plants make their firſt appearance; the covering in whole four or five inches. In this ſtate they remain without any hoeing till the crop is taken up. The produce on Mr Smith's moſs has never been leſs than from forty to fifty bolls of excellent potatoes, eight Wincheſter buſhels to the boll, and the buſhel a little heaped.

"When the potatoe crop is removed, the ridges are again formed as before deſcribed, and the diviſion-furrow cleared out. In performing this part of the work, it will naturally occur, that a great part of the manured ſurface will be buried in filling up the trenches between the potatoe beds: but that is not the caſe; the workman makes two cuts with the ſpade, at eighteen inches diſtance, upon the ſide of the trench; another, one foot from the edge of it, as deep as the trench; which, inſtead of turning over, he preſſes a foot forward into the trench, which is continued the length of it; and when he comes to the other ſide he does the ſame, making both meet, and ſo proceeds; ſo that no part of the manured ſurface is thrown down, and the ridge is left in the ſame form as before the lazy-beds* were made.

"When the potatoe crop is taken off, and the ridges formed as before deſcribed, they remain in that ſtate till ſpring, when oats are ſown (a wet or dry ſeaſon has

from

* This is a vulgar Scottiſh phraſe for beds of a particular kind of potatoe.

Moſs.

from experience been found a matter of indifference), and harrowed in with a ſmall harrow drawn by two men. Four men with eaſe harrow at leaſt one acre one rood per day, two and two by turns with the harrow, and the other two in the interim with ſpades, ſmoothing the inequalities, breaking and dividing the mould, and clearing out the diviſion furrows; which laſt in all operations upon moſs are eſſentially neceſſary. The early or hot ſeed oats are always preferred for ſeed. The late or cold ſeed runs too much to ſtraw, falls down, and becomes ſloomy, conſequently the grain is of mean quality, and unproductive in meal.

“ The produce of the firſt crop of oats after potatoes is ſeldom leſs than ten bolls per acre, the Linlithgow boll of ſix Wincheſter buſhels, and conſiderably more has been known; as good grain in quality, and meals as well as any in the country. It has been ſold when growing, what is called upon the foot, including the ſtraw, from eight to ten pounds per acre. To prepare for a ſecond crop of oats, the ridges muſt be dug acroſs, and turned over in the manner before deſcribed, and the diviſion furrows cleared out as ſoon as convenient after the firſt crop is removed.

“ Such is the effect of lime in conſolidating moſs, aided by the draining, that often after the ſecond, and always after the third year, it can be ploughed by horſes within two bouts or ſtitches of the diviſion furrow; and alſo harrowed by horſes, and the crops taken off by carts.

“ Five and often ſix conſecutive crops of oats are taken, without any other manure than what it received the firſt year for potatoes, without any apparent ſigns of it being exhauſted. The produce of the firſt two crops of oats has been mentioned to be ten bolls, and the third, fourth, fifth, and ſixth, produce from ſix to ten bolls per acre. The moſs is now turned into a ſeeming rich dark brown mould; and what renders it leſs productive of corn crops the fourth, fifth, and ſixth years is, its naturally running into ſweet and luxuriant graſſes. The ſoft meadow graſs, the daiſy, ſome plaintain, but principally the white clover, are the moſt prevalent graſſes; or more probably it may be aſcribed to theſe crops being ploughed, in place of being dug with the ſpade, as the former years were. Along with the fifth or ſixth crop of oats, rye-graſs is ſown, which, with the natural graſſes in general, produce an abundant crop of hay.

“ If the moſs in the original ſtate has been wet and ſpongy, it will be found to have ſubſided ſome feet after the third or fourth year's operation has been performed; but care muſt always be taken to deepen, clear out, and keep clear the main drains and the diviſion furrows, to prevent a ſuperabundance of moiſture, which would infallibly be the caſe were they neglected in conſequence of the ſubſidence of the moſs. Indeed moſs of all ſorts will ſubſide leſs or more, in proportion as it has been dry or wet in its original ſtate; at the ſame time, as ſtated before, care muſt be taken not to lay it too dry, but to keep in a proper degree of temperature between theſe two extremes.”

By having recourſe to the pamphlet from which this extract has been made, the reader may ſatiſfy himſelf of the real advantages of this ſpecies of agriculture. The author calculates, with much apparent fairneſs, the expence of improvement, and the value of each crop, and concludes that no waſte can be improved with equal advantage as moſs. It muſt not, however, be concealed, that we have heard practical farmers, who ſeemed to be acquainted with the ſubject, give it as their opinion that this mode of cultivation anſwers only in moſſes of no great depth; though our author affirms that it has with great ſucceſs been practiſed by Mr Smith in moſſes of the depth of 14 feet.

Motion.

MOTION in fluids. When in the publication of this *Supplement* we had arrived at the title Fluids, we were ſtruck with the importance given, in ſome of the journals, to *The Experimental Reſearches of* Venturi *concerning the Principle of the lateral communication of Motion in Fluids, applied to the Explanation of various Hydraulic Phenomena.* Of theſe reſearches we intended to lay an abridged account before our readers under the preſent title; but having examined the work with ſome attention, we find in it hardly any thing of conſequence which the mechanical philoſopher may not learn from our articles *Resistance of Fluids* and River in the *Encyclopædia.* That our readers, however, may find ſomething under a title to which we raſhly referred them, we ſhall, in the words of Nicholſon's Journal of Natural Philoſophy, &c. inform them what Venturi's work contains.

“ This author, who is profeſſor of experimental philoſophy at Modena, has introduced an horizontal current of water into a veſſel filled with the ſame fluid at reſt. This ſtream entering the veſſel with a certain velocity, paſſes through a portion of the fluid, and is then received in an inclined channel, the bottom of which gradually riſes until it paſſes over the border or rim of the veſſel itſelf. The effect is found to be, not only that the ſtream itſelf paſſes out of the veſſel through the channel, but carries along with it the fluid contained in the veſſel; ſo that after a ſhort time no more of the fluid remains than was originally below the aperture at which the ſtream enters. This fact is adopted as a principle or primitive phenomenon by the author, under the denomination of the lateral communication of motion in fluids, and to this he refers many important hydraulic facts. He does not undertake to give an explanation of this principle, but ſhews that the mutual attraction of the particles of water is far from being a ſufficient cauſe to account for it.

The firſt phenomenon which the author propoſes to explain by this eſtabliſhed principle, is the emiſſion of a fluid through different adjutages applied to the reſervoir which contains it. It is known that the vein of fluid which iſſues from an orifice or perforation through a thin plate, becomes contracted, ſo as to exhibit a ſection equal to about 0,64 of the orifice itſelf, ſuppoſed to be circular; and that the place of the greateſt contraction is uſually at the diſtance of one ſemi-diameter of the orifice itſelf. If a ſmall adjutage be adapted to the orifice, having its internal cavity of the ſame conoidal form as the fluid itſelf affects in that interval, the expenditure is the ſame as by the ſimple orifice. But if at the extremity of this adjutage a cylindric tube be affixed, of a greater diameter than that of the contracted vein, or a divergent conical tube, the expence of fluid increaſes, and may exceed the double of that which paſſes through the aperture in the thin plate, though the adjutage poſſeſs an horizontal or even aſcending direction.

By the interpoſition of a ſmall adjutage, adapted to the form of the contracted vein, Venturi aſcertained, in the firſt place, that there is an increaſe of velocity in the tubes he employed, though the velocity of emiſſion itſelf be leſs than that of the ſtream which iſſues from a hole in a thin plate. He afterwards proves, by the fact, that the interior velocity and expenditure of fluid, which is increaſed through tubes, even in the horizontal or aſcending direction, is owing to the preſſure of the atmoſphere. If the ſmalleſt hole be made in the ſide of the tube near the place of contraction of the vein, the increaſed expenditure does not take place; and when a vertical tube is inſerted in ſuch a hole, the lower end of which tube is immerſed in water or mercury, it is found that aſpiration takes place, and the water or mercury riſes; and this aſpiration in conical tubes is leſs in proportion, as the place of inſertion of the upright tube is more remote from the ſection where the greateſt contraction would have taken place. And, laſtly, the difference between the expenditure of fluid, through an orifice made in a thin plate, and that which is obſerved through an additional tube, does not take place in vacuo.

The influence of the weight of the atmoſphere on the horizontal or aſcending flux being thus eſtabliſhed, the author conſiders it as a ſecondary cauſe, referable to, and explicable by, his principle of the lateral communication of motion in fluids. In conical divergent tubes, for example, the effect of this lateral communication is, that the central cylindrical jet, having for its baſis the ſection of the contracted vein, carries with it the lateral fluid which would have remained ſtagnant in the enlarged part of the cone. Hence a vacuum tends to be produced in this enlarged part which ſurrounds the central cylindric ſtream; the preſſure of the atmoſphere becomes active to ſupply the void, and is exerted on the ſurface of the reſervoir, ſo as to increaſe the velocity of the fluid at the interior extremity of the tube.

The author proves, that the velocity or total expenditure of fluid through an aperture of given dimenſions, may be increaſed by a proper adjutage in the proportion of 24 to 10: he applies this reſult to the conſtruction of the funnels of chimneys. He determines the loſs of emitted fluid, which may be ſuſtained by ſinuoſity in pipes. He ſhews by experiment, that a pipe which is enlarged in any part affords a much leſs quantity of fluid than if it were throughout of a diameter equal to that of its ſmalleſt ſection. This, as he remarks, is a circumſtance to which ſufficient attention has not been paid in the conſtruction of hydraulic machines. It is not enough to avoid elbows and contractions; for it ſometimes happens that, by an intermediate enlargement, the whole of the advantage ariſing from other judicious diſpoſitions of the parts of the machine is loſt.

There are two cauſes of the increaſe of expenditure through deſcending pipes. The firſt is owing to the lateral communication of motion which takes place in deſcending pipes, in the ſame manner as in thoſe which poſſeſs an horizontal ſituation; the ſecond ariſes from the acceleration by gravity which takes place in the fluid while it falls through the deſcending tube. This ſecond kind of augmentation was known to the ancients, though they poſſeſſed no good theory nor deciſive experiments reſpecting it. The author endeavours to eſtabliſh a theory on the principle of virtual aſcenſion combined with the preſſure of the atmoſphere. His deductions are confirmed by experiment, in which he has ſucceeded ſo far as to ſeparate the two cauſes of augmentation, and aſſigned to each their reſpective degree of influence.

Profeſſor Venturi then proceeds to different objects of enquiry, to which his principle ſeemed applicable. He gives the theory of the water-blowing machine (ſee *Water Blowing Machine* in this *Suppl.*), and he determines by calculation the quantity of air which one of theſe machines can afford in a given time. He obſerves, that the natural falls of water in the mountains always produce a local wind; and he even thinks, that the falling ſtreams in the internal parts of mountains are in ſome inſtances the cauſe of the winds which iſſue from caves. He proves, by the facts, that it is poſſible, in certain inſtances, to carry off, without any machinery, the waters from a ſpot of ground, though it may be ſituated on a lower level than that of the channel which is to receive the water.

The whirlpools, or circular eddies of water ſo frequent in rivers, are, according to the theory of our author, the effect of motion communicated from the parts of the current which are moſt rapid, to thoſe lateral parts which are leaſt ſo. In the application of this principle, he points out the circumſtances adapted to produce ſuch eddies at the ſurface or at the bottom of rivers. He concludes, that every movement of this kind deſtroys a part of the force of the current, and that in a channel through which water conſtantly flows, the height of this fluid will be greater than it would have been if the dimenſions of the channel had been uniformly reduced to the meaſure of its ſmalleſt ſection.

There is another kind of whirling motion ſomewhat different in its nature from theſe laſt. It is produced in the water of a reſervoir, when it is ſuffered to flow through an horizontal orifice. The author deduces the theory of theſe vortices from the doctrine of central forces. The form of the hollow funnel, which in this caſe opens through the fluid of the reſervoir, is a curve of the 64th ſpecies of the lines of the third order, enumerated by Newton. Theory and experiment both unite here in proving, that it is not only poſſible, but that there really exiſts in nature a vortex, the concavity of which is convex towards the axis, and of which the revolutions of its different parts follow the ratio of the ſquare of the diſtance from the centre. Daniel Bernoulli was in the wrong, in his Hydrodynamics, to reproach Newton for having ſuppoſed a vortex to be moved according to this law.

In the laſt place, the author conſiders that lateral communication of motion which takes place in the air as well as in the water. This is the cauſe of ſuch local and partial winds as ſometimes blow contrary to the direction of the general wind. It is by virtue of the ſame principle, that the reſonant vibration, excited laterally in the extremity of an organ-pipe, is communicated to the whole column of air contained in the pipe itſelf.

From the ſame principle, the author deduces the augmentation of force which ſound receives in conical divergent tubes, compared with thoſe of a cylindrical form. On this occaſion, he points out the remarkable differences which appear to take place between the reſonant vibrations of air contained in a tube, and the ſonorous pulſations propagated through the open atmoſphere. See *Speaking Trumpet*, Encycl.

In an appendix, Venturi relates different experiments which he has made to determine the convergence and velocity of the fluid filaments which preſs forward to iſſue out of a reſervoir by an orifice through a thin plate. He proves, by a very clear experiment, that the contraction of the vein is made at a greater diſtance from the orifice under ſtrong than under weak preſſures. He explains why, in a right-lined orifice, the ſides of the contracted vein correſpond with the angles of the orifice and the angles with the ſides. He examines the expenditure through a tube, the extremity of which is thruſt into the reſervoir itſelf, according to the method of Borda in the Memoirs of the Academy of Sciences for the year 1766."

For a full account of the author's experiments, and his deductions from them, we refer the reader either to the original work, intitled, *Recherches expérimentales ſur le Principe de la Communication latérale du Mouvement dans les Fluides, appliqué à l'Explication de différens Phénomènes hydrauliques. Par le Citoyen J. B. Venturi, Profeſſeur de Phyſique expérimentale à Modène, Membre de la Societé Italienne, &c. &c. A Paris chez Houel et Ducros, Rue du Bacq,* N° 940—*Théophile Barrois, Rue Haute-feuille,* N° 22. *Ann.* VI. 1797—or to the 2d and 3d vols of the valuable Journal from which this abſtract is taken.

MOURZOUK, the capital of Fezzan in Africa, is ſituated on a ſmall river, and ſupplied with water from a multitude of ſprings and wells. Being formerly built of ſtone, it ſtill retains the appellation of a Chriſtian town; and the medley which it preſents to the eye, of the vaſt ruins of ancient buildings, and the humble cottages of earth and ſand that form the dwellings of its preſent Arab inhabitants, is ſingularly groteſque and ſtrange. It is ſurrounded by a high wall, which not only affords the means of defence, but enables the government to collect, at its three gates, a tax on all goods (proviſions excepted) that are brought for the ſupply of its people. A caravan ſets out annually from Meſurata to this place; and hence the Fezzaners themſelves diſpatch every year a caravan to Caſhna and another to Bornou. For the latitude of Mourzouk, ſee Fezzan in this *Suppl.* Dr Brookes, in his Gazetteer, places it in 15° 5′ E. Long.

MOWAZZEF, in Bengal, fixed revenue.

MOZART, the celebrated German muſician, was born at Salzburg in the year 1756. His father was alſo a muſician of ſome eminence, but not to be compared with the ſon; of whom we have the following account in one of the monthly miſcellanies, taken by Mr Buſhby from ſome biographical ſketches by two eminent German profeſſors.

At the age of three years, young Mozart, attending to the leſſons which his ſiſter, then ſeven years old, was receiving at the harpſichord, he became captivated with harmony; and when ſhe had left the inſtrument, he would inſtantly place himſelf at it, find the thirds, ſound them with the livelieſt joy, and employ whole hours at the exerciſe. His father, urged by ſuch early and ſtriking indications of genius, immediately began to teach him ſome little airs; and ſoon perceived that his pupil improved even beyond the hopes he had formed of him. Half an hour was generally ſufficient for his acquiring a minuet or a little ſong, which, when once learned, he would of himſelf perform with taſte and expreſſion.

At the age of ſix years he had made ſuch a progreſs as to be able to compoſe ſhort pieces for the harpſichord, which his father was obliged to commit to paper for him. From that time nothing made any impreſſion upon him but harmony; and infantine amuſements loſt all their attractions unleſs muſic had a ſhare in them. He advanced from day to day, not by ordinary and inſenſible degrees, but with a rapidity which hourly excited new ſurpriſe in his parents—the happy witneſſes of his progreſs.

His father returning home one day with a ſtranger, found little Mozart with a pen in his hand. "What are you writing," ſaid he? "A concerto for the harpſichord," replied the child. "Let us ſee it (rejoined the father); it is a marvellous concerto without doubt." He then took the paper, and ſaw nothing at firſt but a maſs of notes mingled with blots of ink by the mal addreſs of the young compoſer, who, unſkilled in the management of the pen, had dipped it too freely in the ink; and having blotted and ſmeared his paper, had endeavoured to make out his ideas with his fingers; but on a cloſer examination, his father was loſt in wonder; and his eyes delighted and flowing with tears, became rivetted to the notes. "See (exclaimed he to the ſtranger) how juſt and regular it all is! but it is impoſſible to play it; it is too difficult." "It is a concerto (ſaid the child), and muſt be practiſed till one can play it. Hear how this part goes." He then ſat down to perform it; but was not able to execute the paſſages with ſufficient fluency to do juſtice to his own ideas. Extraordinary as his manual facility was univerſally allowed to be for his age, it did not keep pace with the progreſs of his knowledge and invention. Such an inſtance of intellectual advancement, in a child only ſix years of age, is ſo far out of the common road of nature, that we can only contemplate the fact with aſtoniſhment, and acknowledge, that the poſſible rapidity of mental maturation is not to be calculated.

In the year 1762, his father took him and his ſiſter to Munich, where he performed a concerto before the elector, which excited the admiration of the whole court; nor was he leſs applauded at Vienna, where the emperor called him the *little ſorcerer*.

His father gave him leſſons only on the harpſichord; but he privately taught himſelf the violin; and his command of the inſtrument afforded the elder Mozart the utmoſt ſurpriſe, when he one day at a concert took a ſecond violin, and acquitted himſelf with more than paſſable addreſs. True genius ſees no obſtacles. It will not therefore excite our wonder, if his conſtant ſucceſs in whatever he attempted begot an unbounded confidence in his own powers; he had even the *laudable* hardihood to undertake to qualify himſelf for the *firſt* violin, and did not long remain ſhort of the neceſſary proficiency.

He had an ear ſo correct, that he felt the moſt minute diſcordancy; and ſuch a fondneſs for ſtudy, that it was frequently neceſſary to take him by force from the inſtrument. This love of application never diminiſhed. He every day paſſed a conſiderable time at his harpſichord, and generally practiſed till a late hour at night. Another characteriſtical trait of real genius; always full of its object, and loſt as it were in itſelf.

In the year 1763 he made, with his father and ſiſter, his firſt grand muſical journey. He viſited Paris; and was heard by the French court in the chapel-royal at Verſailles, where his talent on the organ was admired even more than on the harpſichord. At Paris the muſical travellers gave two concerts, which procured them the higheſt reputation, and the diſtinction of public portraits. It was here that a ſet of ſonatas for the harpſichord, ſome of his earlieſt compoſitions, were engraved and publiſhed.

From Paris they went to London, where they alſo gave two concerts, conſiſting of ſymphonies compoſed by young Mozart, who even at that early age ſang alſo with much expreſſion, and practiſed publicly with his ſiſter. Mozart played already at ſight, and in a concert, at which the king was one of his auditors, a baſs being placed before him as a *ground*, immediately applied to it a moſt beautiful melody. Thoſe who are beſt acquainted with the extent of ſuch a taſk, will be the moſt aſtoniſhed at ſuch mature familiarity with the intricacies of the ſcience, and ſuch prompt and ready invention in ſo juvenile a mind.

From London, where Mozart alſo publiſhed ſix ſonatas for the harpſichord, the muſical family went to Holland, thence again to France, and in 1766 returned to Salzburg. There this extraordinary youth remained more than a year in perfect repoſe; devoting the whole of his time to the ſtudy of compoſition, the principles of which he ſcrutinized with the depth and penetration of confirmed manhood. Emmanuel Bach, Haſſe, and Handel, were his chief guides and models; though he by no means neglected the old Italian maſters.

In 1768 he again viſited Vienna, where Joſeph II. engaged him to ſet to muſic a comic opera, entitled, *La Finta Semplice*, which obtained the approbation of Haſſe and Metataſio. At the houſe of the prince of Kaunitz, it often happened that the firſt Italian air which came to hand would be given him, that in the preſence of the company he might add to it accompaniments for numerous inſtruments; which he would write in the firſt ſtyle of excellence, and without the leaſt premeditation. This is at once a proof with what acuteneſs of obſervation he had liſtened to the muſic of the beſt maſters; how intimate he had already rendered himſelf with the characters, capacities, and effects of the different inſtruments; and what ſkill he had acquired in that abſtruſe art of mixed combination which, while it calculates the conjoint effect of ſounds, as they regard the eſtabliſhed laws of harmony, accommodates the different parts to the ſcales, tones, and powers of the reſpective inſtruments by which they are to be executed. It was at this time alſo that, although but twelve years of age, he compoſed the muſic for the conſecration of the church of orphans, at the performance of which he himſelf preſided.

In 1769 Mozart again returned to Salzburg, where he became *maitre de concert*. Not having yet ſeen Italy, in December of the ſame year he ſet out for that ſeat of the fine arts. Thoſe talents which had already excited the admiration of Germany, France, and England, now awakened in that land of muſical taſte the moſt lively enthuſiaſm.

In 1771 he had no ſooner given perſonal proofs of his genius, than *la ſcrittura* for the following carnival was conferred upon him. He viſited Bologna, then as famous for harmonic excellence as Naples, where the celebrated theoriſt Martini was amazed to ſee a German boy work and execute the theme of a fugue which he preſented to him, in the extraordinary ſtyle in which Mozart acquitted himſelf. He next went to Florence. Florence even enhanced the eulogiums which Bologna had laviſhed upon him.

During the holy week he arrived at Rome, and aſſiſted at the *Miſerere* in the Sixtine chapel; which performance is juſtly conſidered as the *ne plus ultra* of vocal muſic. This circumſtance claims particular notice, as inducing a proof of another faculty of his mind, only to be equalled by thoſe wonderful powers which he had already demonſtrated. He was prohibited from taking a copy of this *Miſerere*, and therefore piqued himſelf on retaining it in his memory. Having heard it with attention, he went home, made out a manuſcript from recollection, returned the next day to the chapel, heard the piece a ſecond time, corrected the rough draught, and produced a tranſcript which ſurpriſed all Rome. This *Miſerere* formed a *ſcorer* numerous in its parts, and extremely difficult of execution. His mind had embraced and retained the whole!

He ſoon after received from the Pope the order of the gilt ſpur; and at Bologna was complimented, by an unanimous deciſion, with the title of *Member and Maſter of the Phil-harmonic Academy*. As a proof, *pro forma*, of his qualifications for this academical honour, a fugue, for four voices, in the church ſtyle, was required of him, and he was ſhut up alone in his chamber. He completed it in half an hour, and received his diploma. This evinced that he poſſeſſed an imagination conſtantly at his command, and that his mind was ſtored with all the riches of his beloved ſcience.

The opera which he compoſed for Milan was called *Mithridates*. This piece procured him *la ſcrittura* for the grand opera of the carnival of 1773, which was his *Lucio Sulla*. At length, after a tour of fifteen months, he returned to Salzburg.

In 1771 Mozart viſited Paris; but not reliſhing the muſic of that capital, he ſoon quitted it, and returned to his domeſtic comforts. In 1781, at the requeſt of the elector of Bavaria, he compoſed the opera of *Idomeneo* for the carnival of that year. The general merit of this opera is ſo great, that it might ſerve alone for the baſis of a diſtinguiſhed reputation. At his twenty-fifth year he was invited to Vienna, where he continued ſpreading, as from a centre, the taſte of his compoſitions through all Germany, and the luſtre of his name over the whole of Europe.

Of all the virtuoſi of the piano forte who then crowded Vienna, Mozart was much the moſt ſkilful. His finger was extraordinarily rapid and taſteful, and the execution of his left hand exceeded every thing that had before been heard. His touch was replete with delicacy and expreſſion; and the profound ſtudy he had beſtowed on his art, gave his performance a ſtyle the moſt brilliant and finiſhed. His compoſitions had a rapid circulation; and in every new piece the connoiſſeurs were ſtruck with the originality of its caſt, the novelty of the paſſages, and the energy of the effect.

Joſeph II. ſolicitous for the perfection of the German opera, engaged Mozart to compoſe a piece. He accordingly produced *L'enlevement du Serail*; performed for the firſt time in 1782. It excited the jealouſy of the Italian company, who therefore ventured to cabal againſt it. The emperor, addreſſing himſelf to the compoſer, ſaid, "It is *too fine* for our ears, my dear Mozart, and moſt *charmingly crowded* with notes." "Preciſely what it ought to be," replied the ſpirited muſician, who juſtly ſuſpected that this remark had been ſuggeſted to Joſeph by the envious Italians. "Though I cannot deſcribe, as an auricular evidence, (ſays the faithful author of the biography), the applauſes and the admiration which this opera produced at Vienna, yet I have witneſſed the enthuſiaſm it excited at Prague among all the connoiſſeurs, as well as among thoſe whoſe ears were leſs cultivated. It was ſaid, that all which had been heard before was not muſic: it drew the moſt overflowing audiences: every body was amazed at its new traits of harmony, and at paſſages ſo original, and till then ſo unheard from wind inſtruments."

The cautious reader will perhaps heſitate to admit, in its fulleſt extent, this account by the author of the biography; but even after an allowance for ſome exaggeration, the moſt phlegmatic will grant that much muſt have been atchieved by this great maſter, to afford a baſis for ſo glowing a picture of the merit and ſucceſs of *L'enlevement du Serail*. During the compoſition of this opera, he married Mademoiſelle Weber, a diſtinguiſhed virtuoſa; and the piece was ſuppoſed to owe to this felicitous circumſtance much of that endearing character, that tone of tenderneſs, and that expreſſion of the ſofter paſſions, which form its principal attractions.

"The Marriage of Figaro," which was in the higheſt repute at all the theatres, was in the year 1787 transformed into an Italian opera; and Mozart, at the inſtance of the emperor, ſet it to muſic. This piece was highly received everywhere, and kept poſſeſſion of the theatre at Prague during almoſt the whole of the winter in which it firſt appeared: numerous extracts were made from it, and the ſongs and dances of Figaro were vociferated in the ſtreets, the gardens, and the taverns. Mozart came that very winter to Prague, and performed in public on the piano forte. His auditors at all times liſtened to him with admiration; but whenever he played extempore, and indulged the ſpontaneous and uninterrupted ſallies of his fancy, which he ſometimes would for more than half an hour, every one was ſeized with the moſt enthuſiaſtic raptures, and acknowledged the unrivalled reſources of his imagination. About this time the manager of the theatre contracted with him for the compoſition of a new opera, which, when produced, was called *Il diſſoluto Punito*, or *Don Giovanni*. His reputation was now ſo exalted, that the Bohemians piqued themſelves on the circumſtance that this opera was compoſed for their entertainment.

But this fame, this great and univerſal applauſe, had not yet produced to the admired artiſt any ſolid advantages; he had obtained no place, no ſettled income; but ſubſiſted by his operas, and the inſtructions and occaſional concerts which he gave. The profits of theſe proved inſufficient for the ſtyle which he was obliged to ſupport; and his finances became much deranged. The critical ſituation in which he now found himſelf, made him reſolve to quit Vienna, and ſeek an aſylum in London; to which metropolis he had often been invited; but Joſeph nominating him *compoſiteur de la chambre*, though, with a very inadequate ſalary, he was induced to accept it; and Germany had the advantage of retaining him.

It is lamentable that premature genius too rarely enjoys a long career: The acceleration of nature in the mental powers ſeems to hurry the progreſs of the animal œconomy, and to anticipate the regular cloſe of temporal exiſtence.

In the year 1791, Mozart, juſt after he had received the appointment of *Maitre de chapelle* of the church of St Peter, and when he was only thirty-five years of age, paid the laſt tribute; and left the world at once to admire the brilliancy, and lament the ſhortneſs of his earthly ſojournment.

Indefatigable, even to his death, he produced, during the laſt few months of his life, his three great maſter pieces *La Flutte Enchantée*, *La Clemence de Titus*, and a *Requiem*, his laſt production. *La Flutte Enchantée* was compoſed for one of the theatres at Vienna; and no dramatic *Olio* could ever boaſt a greater ſucceſs. Every air ſtruck the audience with a new and ſweet ſurpriſe; and the *tout enſemble* was calculated to afford the deepeſt and moſt varied impreſſions. This piece had, in fact, ſo great a number of ſucceſſive repreſentations, that for a long time it was unneceſſary to conſult the opera-bill; which only announced a permanent novelty. And the airs ſelected from it, and repeated throughout the empire, as well in the cottage as in the palace, and which the echoes have reſounded in the moſt diſtant provinces, favoured the idea that Mozart had actually the deſign to enchant all Germany with his *Flutte Enchantée*.

La Clemence de Titus was requeſted by the ſtates of Bohemia for the coronation of Leopold. The compoſer began it in his carriage during his route to Prague, and finiſhed it in eighteen days.

Some circumſtances attending the compoſition of the piece which we have already mentioned as the laſt effort of his genius, are too intereſting to be omitted. A ſhort time before his death, a ſtranger came to him with the requeſt that he would compoſe, as ſpeedily as poſſible, a *requiem* for a catholic prince, who, perceiving himſelf on the verge of the grave, wiſhed, by the execution of ſuch a piece, to ſoothe his mind, and familiariſe it to the idea of his approaching diſſolution. Mozart undertook the work; and the ſtranger depoſited with him as a ſecurity 400 ducats, though the ſum demanded was only 200. The compoſer immediately began the work, and during its progreſs felt his mind unuſually raiſed and agitated. He became at length ſo infatuated with his *requiem*, that he employed not only the day, but ſome hours of the night in its compoſition. One day, while he was converſing with Madame Mozart on the ſubject, he declared to her that he could not but be perſuaded that it was for himſelf he was writing this piece. His wife, diſtreſſed at her inability to diſſipate ſo melancholy an impreſſion, prevailed on him to give her the *ſcore*. He afterwards appearing ſomewhat tranquillized, and more maſter of himſelf, ſhe returned the *ſcore* to him, and he ſoon relapſed into his former deſpondency. On the day of his death he aſked for the *requiem*, which was accordingly brought to his bed: "Was I not right (ſaid he), when I declared that it

Mozart.

Mozart, Mumbo.

was for myſelf I was compoſing this funeral piece?" And the tears trickled from his eyes. This production of a man, impreſſed during its compoſition with a preſentiment of his approaching death, is *unique* in its kind, and contains paſſages which have frequently drawn tears from the performers.

Only one complaint eſcaped him during his malady: "I muſt quit life (ſaid he), preciſely at the moment when I could enjoy it, free from care and inquietude; at the very time when, independent of ſordid ſpeculations, and at liberty to follow my own principles and inclinations, I ſhould only have to write from the impulſes of my own heart: and I am torn from my family juſt when in a ſituation to ſerve it." Mozart, at the time of his death, was conſiderably involved in debt; but Vienna and Prague diſputed the honour of providing for his widow and children.

The countenance of this great maſter did not indicate any thing uncommon. He was ſmall of ſtature; and, except his eyes, which were full of fire, there was nothing to announce ſuperiority of talent. His air, unleſs when he was at the harpſichord, was that of an abſent man. But when he was performing, his whole phyſiognomy became changed: a profound ſeriouſneſs recalled and fixed his eyes; and his ſentiments were expreſſed in every movement of his muſcles. Never has a muſician more ſucceſsfully embraced the whole extent of his art, and ſhone with greater luſtre in all its departments. His great operas, no leſs than his moſt ſimple ſongs; his learned ſymphonies as well as his airy dances—all carry the ſtamp of the richeſt imagination, the deepeſt ſenſibility, and the pureſt taſte. All his works develope the originality of his genius; and imply a mind great and exalted; an imagination which ſtrikes out for itſelf a new courſe. He therefore merits to be ranked with that ſmall number of original geniuſes, thoſe *phænomena ſplendida*, who form an epoch in their art, by carrying it to perfection, or giving it an unknown career.

It is in the employment of wind inſtruments that Mozart diſplays his greateſt powers. His melody is always ſimple, natural, and full of force; and expreſſes with preciſion the ſentiments and individual ſituations of his perſonages. He wrote with extraordinary facility. "*La Clemence de Titus,*" the reader will recollect, coſt him the ſtudy of but eighteen days; and his *requiem*, which is equal in length to an opera, was produced in four weeks. It is alſo worthy of remark, that the overture to his *Don Giovanni* was not begun till the night before the piece was to be performed. At midnight, after having devoted the evening to amuſement, he locked himſelf up in his ſtudy, and compoſed it in a few hours. His memory was wonderfully retentive, as we may judge from his copying by recollection the *miſerere* at Rome. But a fact equally aſtoniſhing is, that, ſoon diſcovering the eagerneſs of people to procure his works, and fearful that they might be pirated, it was his conſtant cuſtom to tranſcribe from the *ſcores* of his ſonatas only a part for one hand, and at the public performance to ſupply the other by memory.

He very early began to diſplay that true dignity of an artiſt which renders him indifferent to the praiſes of thoſe who are unqualified to judge. The commendations of the ignorant great he never conſidered as fame. His hearers, whether the wealthy or the titled, muſt have acquired ſome credit for their judgment before he could be ambitious of their applauſe. Indeed he entertained ſo juſt a ſenſe of ſcientific elevation and importance, that he would inſiſt upon reſpect. And the leaſt noiſe or idle babble, while he was at the inſtrument, excited a diſpleaſure which he was too indignant to conceal. Once, to the honour of his feelings, he ſuddenly roſe from his ſeat, and left his inattentive auditory to experience the keen though ſilent reproach of inſulted genius.

His mind was by no means unlettered; nor was it embelliſhed with one ſcience alone. He was maſter of ſeveral languages, and had made conſiderable progreſs in the mathematics. He was honeſt, mild, generous, full of frankneſs; and with his friends had an air at once amiable, gay, and free from the leaſt tincture of pedantry.

Far from viewing with envy the ſucceſs of others, a weakneſs too cloſely interwoven in the general nature of man, he was always juſt to the talents of his fellow profeſſors; and valued and reſpected merit wherever he found it; a clearer proof of which cannot be adduced than the following circumſtance: At a concert, where a new piece compoſed by the celebrated Joſeph Haydn was performed, a certain muſician, who never diſcovered any thing worthy of praiſe except in his own productions, did not fail to criticiſe the muſic; exclaiming to Mozart, "There now! there again! why, that is not what *I* ſhould have done:" "No; neither ſhould I (replied Mozart); but do you know why? Becauſe neither you nor I ſhould have been able to conceive it."

MUMBO-JUMBO, a ſtrange bugbear employed by the Pagan Mandingoes (ſee MANDING, *Suppl.*) for the purpoſe of keeping their women in ſubjection. Polygamy being allowed among theſe people, every man marries as many wives as he can conveniently maintain; and the conſequence is, that family quarrels ſometimes riſe to ſuch a height, that the huſband's authority is not ſufficient to reſtore peace among the ladies. On theſe occaſions, the interpoſition of *Mumbo-Jumbo* is called in; and it is always deciſive. This ſtrange miniſter of juſtice, who is either the huſband himſelf, or ſome perſon inſtructed by him, diſguiſed in a ſort of maſquerade habit, made of the bark of trees, and armed with the rod of public authority, announces his coming by loud and diſmal ſcreams in the woods near the town. He begins the pantomime at the approach of night; and as ſoon as it is dark, he enters the town, and proceeds to the *Bentang* or market-place, at which all the inhabitants immediately aſſemble.

It may eaſily be ſuppoſed that this exhibition is not much reliſhed by the women; for as the perſon in diſguiſe is entirely unknown to them, every married female ſuſpects that the viſit may poſſibly be intended for herſelf; but they dare not refuſe to appear when they are ſummoned; and the ceremony commences with ſongs and dances, which continue till midnight, about which time Mumbo fixes on the offender. This unfortunate victim being thereupon immediately ſeized, is ſtripped naked, tied to a poſt, and ſeverely ſcourged with Mumbo's rod, amidſt the ſhouts and deriſion of the whole aſſembly; and it is remarkable, that the reſt of the women are the loudeſt in their exclamations on this occaſion againſt their unhappy ſiſter. Daylight puts an end to this indecent and unmanly revel. It is truly aſtoniſhing that the women ſhould be deluded by ſo clumſy an impoſture, and that the men ſhould ſo faithfully keep their own ſecret. That the women are deluded ſeems evident; for Mr Park aſſures us, that the dreſs of Mumbo is ſuffered to hang on a tree at the entrance of each town; which could hardly be the caſe, if the women were not perſuaded that it is the dreſs of ſome ſupernatural being.

MUNSHY, a Perſian ſecretary or writer.

MUNSUB, in the language of Bengal, a dignity or command conferred by the emperor.

MUNSUBDAR, a dignitary or commander.

MURRAY (William), afterwards Earl of Manſfield and Lord Chief Juſtice of England, was the fourth ſon of David Viſcount Stormont. He was born on the 2d day of March 1705 at Perth, in the kingdom of Scotland, of which kingdom his father was a peer. His reſidence in Scotland, however, was of ſhort duration; for he was carried up to London at the early age of three years. Hence his total exemption from the peculiarities of the dialect of his native country.

At the age of fourteen he was admitted as a king's ſcholar of Weſtminſter ſchool; and during his reſidence in that ſeminary, ſays his contemporary Biſhop Newton, he gave early proofs of his uncommon abilities, not ſo much in his poetry, as in his other exerciſes; and particularly in his declamations, which were ſure tokens and prognoſtics of that eloquence which grew up to ſuch maturity and perfection at the bar, and in both houſes of parliament. At the election in May 1723, he ſtood firſt on the liſt of thoſe gentlemen who were ſent to Oxford, and was entered of Chriſt Church, June the 18th, in that year. In the year 1727 he had taken the degree of B. A. and on the death of King George the Firſt, was amongſt thoſe of the univerſity who compoſed verſes on that event.

In April 1724 he was admitted a ſtudent of Lincoln's Inn, though he ſtill continued to reſide much in the univerſity; where, on the 26th of June 1730, he took the degree of M. A. and ſoon afterwards left Oxford, determined to make the tour of Europe before he ſhould devote himſelf ſeriouſly to buſineſs. About this period he wrote two letters to a young nobleman on the ſtudy of ancient and modern hiſtory, which are publiſhed by his biographer Mr Holliday, and ſhew how amply his own mind was then ſtored with general literature.

On his return to England he commenced his legal ſtudies; but proceeded not in the way then uſually adopted, of labouring in the chambers of a ſpecial pleader, or copying (to uſe the words of Blackſtone) the traſh of an attorney's office. Being bleſſed with the powers of oratory in their higheſt perfection, and having ſoon an opportunity of diſplaying them, he very early acquired the notice of the chancellor and the judges, as well as the confidence of the inferior practiſers. How much he was regarded in the houſe of lords, Pope's well-known couplet will prove:

> Grac'd as thou art with all the power of words,
> So known, ſo honour'd at the houſe of lords.

The graces of his elocution, however, produced their uſual effect with a certain claſs of people, who would not believe that ſuch bright talents could aſſociate with the more ſolid attainments of the law; or that a man of genius and vivacity could be a profound lawyer. As Pope obſerved at that time,

> The Temple late two brother ſerjeants ſaw,
> Who deem'd each other oracles of law;
> With equal talents theſe congenial ſouls,
> One lull'd the exchequer, and one ſtunn'd the rolls;
> Each had a gravity would make you ſplit,
> And ſhook his head at Murray as a wit.

It is remarkable that this ridiculous prejudice accompanied Lord Manſfield to the end of his judicial life, in ſpite of daily proofs exhibited in the court of King's Bench and in the Houſe of Lords, of very profound knowledge of the abſtruſeſt points of juriſprudence. Lord Cheſterfield has given his ſanction to this unfounded opinion. In a letter to his ſon, dated Feb. 12. 1754, he ſays, "The preſent Solicitor General Murray has leſs law than many lawyers, but he has more practice than any, merely upon account of his eloquence, of which he has a never-failing ſtream."

In the outſet of Lord Manſfield's life, it will be the leſs ſurpriſing, that a notion ſhould have been entertained of his addicting himſelf to the purſuits of Belles Lettres too much, when the regard ſhewn to him by Mr Pope, who deſpotically ruled the regions of literature at that period, is conſidered. That great Poet ſeemed to entertain a particular affection for our young lawyer, and was eager to ſhew him marks of his regard. He addreſſed to him his imitation of the 6th Epiſtle of the Firſt Book of Horace; and even condeſcended to become his maſter in the art of elocution. "Mr Murray (ſays his biographer) was one day ſurpriſed by a gentleman of Lincoln's Inn, who could take the liberty of entering his rooms without the ceremonious introduction of a ſervant, in the ſingular act of practiſing the graces of a ſpeaker at a glaſs, while Pope ſat by in the character of a friendly preceptor. Mr Murray, on this occaſion, paid that poet the handſome compliment of, *Tu es mihi Mecenas* (A)."

Whatever propenſities this ſprightly lawyer might have towards polite literature, he did not permit them to divert his attention from his profeſſion. He ſoon diſtinguiſhed himſelf in an extraordinary manner, as may be ſeen by thoſe who are converſant with, or chuſe to refer to the Books of Reports. In the year 1736, the murder of Captain Porteous by a mob in Edinburgh, after he had been reprieved, occaſioned a cenſure to fall on that city, and a bill of pains and penalties was brought into Parliament againſt the Lord Provoſt and the corporation; which, after various modifications, and a firm and unabated oppoſition in every ſtage of its progreſs, paſſed into a law. In both Houſes Mr Murray was employed as an advocate, and ſo much to the ſatisfaction of his clients, that afterwards, in September 1743, he was preſented with the freedom of Edinburgh in a gold box, profeſſedly, as it was declared,

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(A) It is thus that eminence is attained even by genius, and Mr Murray was properly employed; though we do not clearly perceive the uſe of the glaſs, when his maſter was watching all his geſtures.

red, for his ſignal ſervices by his ſpeeches to both Houſes of Parliament in the conduct of that buſineſs.

On the 24th of November 1738, he had married Lady Elizabeth Finch, daughter of the Earl of Winchelſea, and in the month of November 1742, was appointed Solicitor General in the place of Sir John Strange, who reſigned (B). He likewiſe was choſen to repreſent the town of Boroughbridge in Parliament, for which place he was alſo returned in 1747 and 1754.

In the month of March 1746-7 he was appointed one of the managers for the impeachment of Lord Lovat by the Houſe of Commons, and it fell to his lot to obſerve on the evidence previous to the Lords giving their judgment. This taſk he executed with ſo much candour, moderation, and gentleman-like propriety, that Lord Talbot, at the concluſion of his ſpeech, paid him the following compliment: "The abilities of the learned manager who juſt now ſpoke, never appeared with greater ſplendour than at this very hour, when his candour and humanity has been joined to thoſe great abilities which have already made him ſo conſpicuous, that I hope one day to ſee him add luſtre to the dignity of the firſt civil employment in this nation." Lord Lovat himſelf alſo bore teſtimony to the abilities of his adverſary: "I thought myſelf (ſays his lordſhip) very much loaded by one Murray (C), who your Lordſhips know was the bittereſt evidence there was againſt me. I have ſince ſuffered by another Mr Murray, who, I muſt ſay with pleaſure, is an honour to his country, and whoſe eloquence and learning is much beyond what is to be expreſt by an ignorant man like me. I heard him with pleaſure, though it was againſt me. I have the honour to be his relation, though perhaps he neither knows it nor values it. I wiſh that his being born in the North may not hinder him from the preferment that his merit and learning deſerve."

During the time that Mr Murray continued in office, he ſupported, with great ability, the adminiſtration with which he was connected; and, of courſe, rendered himſelf obnoxious to thoſe who were in oppoſition. Nothing, however, could be urged either againſt his public conduct or his private life; but he was involved in ſome trouble by an ill-deviſed tale, concurring with the known principles of the family of Stormont, to make him ſuſpected of Jacobitiſm. Of this affair, a full and particular account is given by the late Lord Melcombe in the following words:

"Meſſrs Murray, Fawcett, and Stone, were much acquainted, if not ſchool-fellows, in earlier life. Their fortune led them different ways; Fawcett's was to be a country lawyer and recorder of Newcaſtle. Johnſon, now Biſhop of Glouceſter, was one of their aſſociates. On the day the King's birth-day was kept, they dined at the Dean of Durham's at Durham; this Fawcett, Lord Ravenſworth, Major Daviſon, and one or two more, who retired after dinner into another room. The converſation turning upon the late Biſhop of Glouceſter's preferments, it was aſked who was to have his prebend of Durham? The Dean ſaid, that the laſt news from London was, that Dr Johnſon was to have it: Fawcett ſaid, he was glad that Johnſon got off ſo well, for he remembered him a Jacobite ſeveral years ago, and that he uſed to be with a relation of his who was very diſaffected, one Vernon, a mercer, where the Pretender's health was frequently drunk. This paſſing among a few familiar acquaintance, was thought no more of at the time: it ſpread, however, ſo much in the North (how I never heard accounted for), and reached town in ſuch a manner, that Mr Pelham thought it neceſſary to deſire Mr Vane, who was a friend to Fawcett, and who employed him in his buſineſs, to write to Fawcett, to know if he had ſaid this of Johnſon, and if he had, if it was true.

"This letter was written on the 9th of January; it came to Newcaſtle the Friday following. Fawcett was much ſurpriſed; but the poſt going out in a few hours after its arrival, he immediately acknowledged the letter by a long, but not very explicit, anſwer. This Friday happened to be the club day of the neighbouring gentlemen at Newcaſtle. As ſoon as Lord Ravenſworth, who was a patron and employer of Fawcett, came into the town, Fawcett acquainted him with the extraordinary letter he had received; he told him that he had already anſwered it; and being aſked to ſhew the copy, ſaid he kept none; but deſired Lord Ravenſworth to recollect if he held ſuch a converſation at the Deanry of Durham the day appointed for the birth-day. Ravenſworth recollected nothing at all of it: they went to the club together, and Ravenſworth went the next morning to ſee his mother in the neighbourhood, with whom he ſtaid till Monday; but this thing of ſuch conſequence lying upon his thoughts, he returned by Newcaſtle. He and Fawcett had another converſation; and in endeavouring to refreſh each other's memory about this dreadful delinquency of Johnſon, Fawcett ſaid he could not recollect poſitively at ſuch a diſtance of time, whether Johnſon drank theſe healths, or had been preſent at the drinking of them, but that Murray and Stone had done both ſeveral times. Ravenſworth was exceſſively alarmed at this with relation to Stone, on account of his office about the prince; and thus the affair of Johnſon was quite forgotten, and the epiſode became the principal part. There were many more conferences between Ravenſworth and Faw-

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(B) On this occaſion a doggrel poem was publiſhed by one Morgan, a perſon then at the bar, entitled, "The Cauſidicade," in which all the principal lawyers were ſuppoſed to urge their reſpective claims to the poſt. At the concluſion it is ſaid,

Then Murray, prepar'd with a fine panegyric
In praiſe of himſelf, would have ſpoke it like Garrick;
But the Preſident ſtopping him ſaid, "As in truth
"Your worth and your praiſe is in every one's mouth,
"'Tis needleſs to urge what's notoriouſly known,
"The office, by merit, is your's all muſt own;
"The voice of the public approves of the thing,
"Concurring with that of the Court and the King."

(C) One of the evidences againſt him.

cett upon this ſubject, in which the latter always perſiſted that Stone and Murray were preſent at the drinking, and did drink thoſe healths. It may be obſerved here, that when he was examined upon oath, he ſwore to the year 1731 or 1732, at lateſt. Fawcett comes up as uſual about his law buſineſs, and is examined by Meſſrs Pelham and Vane, who never had heard of Murray or Stone being named: he is aſked, and anſwers only with relation to Johnſon, never mentioning either of the others; but the love of his country, his king, and poſterity, burned ſo ſtrongly in Ravenſworth's boſom, that he could have no reſt till he had diſcovered this enormity. Accordingly, when he came to town, he acquainted the miniſtry and almoſt all his great friends with it, and inſiſted upon the removal of Stone. The miniſtry would have ſlighted it as it deſerved; but as he perſiſted, and had told ſo many of it, they could not help laying it before the king, who, though he himſelf ſlighted it, was adviſed to examine it; which examination produced this moſt injudicious proceeding in parliament*."

This is Lord Melcombe's account; and the ſame author informs us, that Mr Murray, when he heard of the committee being appointed to examine this idle affair, ſent a meſſage to the king, humbly to acquaint him, that if he ſhould be called before ſuch a tribunal on ſo ſcandalous and injurious an account, he would reſign his office, and would refuſe to anſwer. It came, however, before the Houſe of Lords, 22d January 1753, on the motion of the Duke of Bedford.

The debate was long and heavy, ſays Lord Melcombe; the Duke of Bedford's performance moderate enough; he divided the Houſe, but it was not told, for there went below the bar with him the Earl Harcourt, Lord Townſhend, the Biſhop of Worceſter, and Lord Talbot only. The Biſhop of Norwich and Lord Harcourt both ſpoke, not to much purpoſe; but neither of them in the leaſt ſupported the Duke's queſtion.

Upon the whole, Lord Melcombe concludes, "It was the worſt judged, the worſt executed, and the worſt ſupported point that I ever ſaw of ſo much expectation."

The King, his late Majeſty, viewed it in its true light; and is reported to have ſaid, "Whatever they were when Weſtminſter boys, they are now my very good friends." He was likewiſe, as we have been informed by a gentleman connected with the family of Stormont, ſo delighted with Mr Murray's ſpeech in his own vindication, that he deſired to have a copy of it, as a model of dignified and candid eloquence. Fawcett, the original author of the ſtory, ſeems indeed to have been a very ſneaking knave, totally unworthy of credit. Biſhop Johnſon, who was overlooked in the turmoil, excited by the ſuppoſed guilt of Murray and Stone (ſee STONE, in this *Suppl.*), went to Fawcett's chambers in the Temple, and deſired an interview. Being told by the ſervant that his maſter was not at home, he renewed his viſit very early next morning, and declared his reſolution to wait till Mr Fawcett ſhould riſe, the laundreſs having inadvertently confeſſed that he was ſtill in bed. Fawcett, upon this, left his thorny pillow with reluctance; for ſomething ſharper than thorns (ſays Mr Holliday) awaited him, which he could not now poſſibly avoid. The reſult of the interview produced expreſſions of deep contrition, together with a letter, addreſſed to the Lord Biſhop of Glouceſter, acknowledging, in the moſt explicit terms, that his Lordſhip was innocent of the charge which he had been the inſtrument of bringing againſt him.

On the advancement of Sir Dudley Rider to the chief juſticeſhip of the King's Bench in 1754, Mr Murray ſucceeded him as attorney general; and on his death, November 1756, again became his ſucceſſor as chief juſtice, when he was created Baron of Mansfield, in the county of Nottingham, with remainder to the heirs male of his body lawfully begotten.

As ſoon as Lord Mansfield was eſtabliſhed in the King's Bench, he began to make improvements in the practice of that court. On the 12th of November, four days after he had taken his ſeat, he made a very neceſſary regulation, obſerving, "Where we have no doubt, we ought not to put the parties to the delay and expence of a farther argument; nor leave other perſons, who may be intereſted in the determination of a point ſo general, unneceſſarily under the anxiety of ſuſpence."

The anxiety of ſuſpence, from this period, was no longer to be complained of in the court of King's Bench. The regularity, punctuality, and diſpatch of the new chief juſtice, afforded ſuch general ſatisfaction, that they, in proceſs of time, drew into that court moſt of the cauſes which could be brought there for determination.

Sir James Burrows ſays, "I am informed, that at the ſittings for London and Middleſex only, there are not ſo few as 800 cauſes ſet down in a year, and all diſpoſed of. And though many of them, eſpecially in London, are of conſiderable value, there are not more, upon an average, than between 20 and 30 ever heard of afterwards in the ſhape of ſpecial verdicts, ſpecial caſes, motions for new trials, or in arreſt of judgment. Of a bill of exceptions there has been no inſtance (I do not include judgments upon criminal proſecutions; they are neceſſary conſequences of the convictions). My reports give but a very faint idea of the extent of the whole buſineſs which comes before the court: I only report what I think may be of uſe as a determination or illuſtration of ſome matter of law. I take no notice of the numerous queſtions of fact which are heard upon affidavits (the moſt tedious and irkſome part of the whole buſineſs). I take no notice of a variety of conteſtations, which, after having been fully diſcuſſed, are decided without difficulty or doubt. I take no notice of many caſes which turn upon a conſtruction ſo peculiar and particular, as not to be likely to form a precedent for any other caſe. And yet, notwithſtanding this immenſity of buſineſs, it is notorious, that, in conſequence of method, and a few rules which have been laid down to prevent delay (even where the parties themſelves would willingly conſent to it), nothing now hangs in court. Upon the laſt day of the very laſt term, if we exclude ſuch motions of the term as by deſire of the parties went over of courſe as peremptories, there was not a ſingle matter of any kind that remained undetermined, excepting one caſe relating to the proprietary Lordſhip of Maryland, which was profeſſedly poſtponed on account of the preſent ſituation of America. One might ſpeak to the ſame effect concerning the laſt day of any former term for ſome years backward."

The ſame author alſo informs us, that, excepting two

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* Lord Melcombe's Diary, p. 220.

caſes, there had not been, from the 6th of November 1756 to the time of his then preſent publication, 26th May 1776, a final difference of opinion in the court in any caſe, or upon any point whatſoever. "It is remarkable, too (he adds), that, excepting theſe two caſes, no judgment given during the ſame period has been reverſed, either in the exchequer chamber or in parliament: and even theſe reverſals were with great diverſity of opinion among the judges." Of the two caſes here mentioned, one was the famous queſtion concerning literary property, which the majority of the judges of the court of King's Bench held to be permanent; and in ſupport of which opinion, ſuch arguments were urged by the chief juſtice, as have not yet perhaps been completely anſwered.

The ill ſucceſs of the war, which had lately been begun, occaſioned a change in the adminiſtration; and the conflicts of contending parties rendered it impracticable for the crown, at that juncture, to ſettle a new miniſtry. In order, therefore, to give pauſe to the violence of both ſides, Lord Mansfield was induced to accept the poſt of chancellor of the exchequer on the 9th of April 1757; which he held until the 2d of July in the ſame year. During this interval, he employed himſelf, with great ſucceſs, to bring about a coalition; which being effected, produced a ſeries of events, which raiſed the glory of Great Britain to the higheſt point at which it has ever been ſeen. In the ſame year he was offered, but refuſed, the office of Lord High Chancellor; and in November 1758, he was elected a governor of the charter houſe, in the room of the Duke of Marlborough, then lately deceaſed.

For ſeveral years after this period, the tenor of Lord Mansfield's life was marked only with a moſt ſedulous diſcharge of the duties of his office. In 1760 Geo. II. died, and the new reign commenced with alterations in the adminiſtration; which gave riſe to a virulent ſpirit of oppoſition, conducted with a degree of violence and aſperity never known at any former time. As a friend to the then adminiſtration, Lord Mansfield was marked out for a more than ordinary ſhare of malicious invective. It is in alluſion to this, that Warburton, after tracing the riſe and progreſs of the irreligion and licentiouſneſs which then prevailed, and obſerving that, amid ſuch general corruption, the pure adminiſtration of public juſtice ſtill afforded a cheerful conſolation to thinking men, proceeds thus:

"But the evil genius of England would not ſuffer us to enjoy it long; for, as if envious of this laſt ſupport of government, he hath now inſtigated his blackeſt agents to every extent of their malignity; who, after the moſt villainous inſults on all other orders and ranks in ſociety, have at length proceeded to calumniate even the king's ſupreme court of juſtice, under its ableſt and moſt unblemiſhed adminiſtration. After this, who will not be tempted to deſpair of his country, and ſay with the good old man in the ſcene,

——"*Ipſa ſi cupiat ſalus*
"*Servare, prorſus non poteſt, hanc Familiam* (D)?"

A change of adminiſtration again took place in 1765, which introduced the Marquis of Rockingham and his friends to govern the country; and the meaſures then adopted not agreeing with Lord Mansfield's ſentiments, he, for the firſt time, became an opponent of government. On the bill for repealing the ſtamp act, he ſpoke, and divided againſt it; and is ſuppoſed to have had ſome ſhare in the compoſition of the proteſts on that occaſion, though he did not ſign them. In the ſame year, he is ſaid to have animadverted, with no ſmall degree of ſeverity, on the incautious expreſſions of Lord Camden, on the affair of prohibiting the exportation of corn, that it was but a 40 days tyranny at the outſide (E).

In 1767, the Diſſenters cauſe was determined, in which Lord Mansfield delivered a ſpeech, which has ſince been printed, and ſhews his Lordſhip to have been a ſteady friend to religious toleration, as well as to the rights of the eſtabliſhed church. The conſcientious Diſſenters themſelves laviſhed upon that ſpeech the higheſt praiſe; whilſt others of them, in the ſucceeding year, deluged the public prints with torrents of abuſe on the Chief Juſtice. In that year was the general election. Mr Wilkes returned from abroad, became a candidate for the city of London, and afterwards was choſen repreſentative for the county of Middleſex. Having been outlawed ſome years before, he now applied for a reverſal of that proceeding. On the 8th of June, the conſideration of it came before the court of King's Bench; when the judges delivered their opinions very fully, and were unanimous that the outlawry was illegal, and muſt be reverſed. On this occaſion Lord Mansfield took the opportunity of entering into a full ſtatement of the caſe, and a juſtification of his own conduct. The reader will find the caſe reported by Sir James Burrow; from whom we ſhall extract the following, which appears to have been the moſt important part of his Lordſhip's ſpeech:

"It is fit to take ſome notice of the various terrors hung out; the numerous crowds which have attended, and now attend, in and about the hall, out of all reach of hearing what paſſes in court; and the tumults which in other places have ſhamefully inſulted all order and government. Audacious addreſſes in print dictate to us, from thoſe they call the people, the judgment to be given now, and afterwards upon the conviction. Reaſons of policy are urged, from danger to the kingdom, by commotions and general confuſion.

"Give me leave to take the opportunity of this great and reſpectable audience, to let the whole world know all ſuch attempts are vain. Unleſs we have been able to find an error which will bear us out to reverſe the outlawry, it muſt be affirmed. The conſtitution does not allow reaſons of ſtate to influence our judgment: God

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(D) See the dedication of the 5th edition of the Divine Legation of Moſes, which deſerves to be read at preſent with peculiar attention, as the work of a man of gigantic talents, deeply read in law as well as in theology.

(E) The ſpeeches in the debate were never printed; but the ſubſtance of them all was conſolidated in a pamphlet publiſhed at the time, intitled, "A Speech againſt the ſuſpending and diſpenſing prerogative," 8vo. Since reprinted in Debrett's Debates, Vol. IV. p. 384.

God forbid it ſhould! We muſt not regard political conſequences, how formidable ſoever they may be; we are bound to ſay, *Fiat Juſtitia, ruat Cœlum.* The conſtitution truſts the king with reaſons of ſtate and policy: He may pardon offences; it is his to judge whether the law or the criminal ſhould yield. We have no election. None of us encouraged or approved the commiſſion of either of the crimes of which the defender is convicted: none of us had any hand in his being proſecuted. As to myſelf, I took no part (in another place) in the addreſſes for that proſecution. We did not adviſe or aſſiſt the defender to fly from juſtice; it was his own act, and he muſt take the conſequences. None of us have been conſulted, or had any thing to do with the preſent proſecution. It is not in our power to ſtop it; it was not in our power to bring it on. We cannot pardon. We are to ſay what we take the law to be. If we do not ſpeak our real opinions, we prevaricate with God and our own conſciences.

“ I paſs over many anonymous letters I have received: thoſe in print are public; and ſome of them have been brought judicially before the court. Whoever the writers are, they take the wrong way. I will do my duty unawed. What am I to fear? That *mendax infamia* from the preſs, which daily coins falſe facts and falſe motives? The lies of calumny carry no terror to me. I truſt, that my temper of mind, and the colour and conduct of my life, have given me a ſuit of armour againſt theſe arrows. If, during this king's reign, I have ever ſupported his government, and aſſiſted his meaſures, I have done it without any other reward than the conſciouſneſs of doing what I thought right. If I have ever oppoſed, I have done it upon the points themſelves, without any collateral views. I honour the king, and reſpect the people. But many things acquired by the favour of either are, in my account, objects not worth ambition. I wiſh popularity; but it is that popularity which follows, not that which is run after.—It is that popularity which, ſooner or later, never fails to do juſtice to the purſuit of noble ends by noble means. I will not do that which my conſcience tells me is wrong upon this occaſion, to gain the huzzas of thouſands, or the daily praiſe of all the papers which come from the preſs. I will not avoid doing what I think is right, though it ſhould draw on me the whole artillery of libels, all that falſehood and malice can invent, or the credulity of a deluded populace can ſwallow. I can ſay with a great magiſtrate, upon an occaſion, and under circumſtances not unlike, ‘*Ego hoc animo ſemper fui, ut invidiam virtute partam, gloriam, non invidiam putarem.*’

“ The threats go further than abuſe: Perſonal violence is denounced. I do not believe it: it is not the genius of the worſt men of this country in the worſt of times. But I have ſet my mind at reſt. The laſt end that can happen to any man never comes too ſoon, if he falls in ſupport of the law and liberty of his country (for liberty is ſynonymous to law and government). Such a ſhock, too, muſt be productive of public good: It might awake the better part of the kingdom out of that lethargy which ſeems to have benumbed them; and bring the mad part back to their ſenſes, as men intoxicated are ſometimes ſtunned into ſobriety.

“ Once for all, let it be underſtood, that no endeavours of this kind will influence any man who at preſent ſits here. If they had any effect, it would be contrary to their intent: Leaning againſt their impreſſion might give a bias the other way. But I hope, and I know, that I have fortitude enough to reſiſt even that weakneſs. No libels, no threats, nothing that has happened, nothing that can happen, will weigh a feather againſt allowing the defendant, upon this and every other queſtion, not only the whole advantage he is intitled to from ſubſtantial law and juſtice, but every benefit from the moſt critical nicety of form, which any other defender could claim under the like objection. The only effect I feel is an anxiety to be able to explain the grounds upon which we proceed; ſo as to ſatisfy all mankind, that a flaw of form given way to in this caſe, could not have been got over in any other.”

In January 1770, Lord Manſfield again was offered the Great Seal, which was given to Mr Charles York: and in Hilary Term 1771, he a third time declined the ſame offer, and the Seal was entruſted to Lord Bathurſt.

The year 1770 was alſo memorable for various attacks made on his Lordſhip's judicial character, in both the Houſes of Lords and Commons. In one of theſe, the propriety of a direction given to the jury in the caſe of the king and Woodfal was called in queſtion; which occaſioned his Lordſhip to produce to the Houſe a copy of the unanimous opinion of the court of King's Bench in that cauſe; which, after being much canvaſſed and oppoſed, was ſuffered to ſtand its ground without being over-ruled.

On the 19th of October 1776, his Lordſhip was advanced to the dignity of an Earl of Great Britain, by the title of the Earl of Manſfield, and to his male iſſue; and for want of ſuch iſſue, to Louiſa Viſcounteſs Stormont, and to her heirs male by David Viſcount Stormont her huſband. The ſame title, in 1792, was limited to Lord Stormont himſelf; who afterwards ſucceeded to it.

We come now to a period of his Lordſhip's life, which furniſhes an event diſgraceful to the age and country in which the fact was committed. An union of folly, enthuſiaſm, and knavery, had excited alarms in the minds of ſome weak people, that encouragements were given to the favourers and profeſſors of the Roman Catholic faith inconſiſtent with religion and true policy. The act of Parliament, which excited the clamour, had paſſed with little oppoſition, and had not received any extraordinary ſupport from Lord Manſfield. The minds of the public were inflamed by artful miſrepreſentations; the rage of a popular mob was ſoon directed towards the moſt eminent perſons. Accordingly, in the night between Tueſday the 6th and Wedneſday the 7th of June 1780, his Lordſhip's houſe in Bloomſbury Square was attacked by a party of rioters, who, on the Friday and Tueſday preceding, had, to the amount of many thouſands, ſurrounded the avenues of both Houſes of Parliament, under pretence of attending Lord George Gordon when he preſented the petition from the Proteſtant Aſſociation. On Tueſday evening the priſon of Newgate had been thrown open, all the combuſtible part reduced to aſhes, and the felons let looſe upon the public. It was after this attempt to deſtroy the means of ſecuring the victims of criminal juſtice that the rioters aſſaulted the reſidence of the chief magiſtrate of the firſt criminal court in the kingdom; nor were they diſperſed till they had burnt all the furniture, pictures, books, manuſcripts, deeds, and, in ſhort, every thing which fire could conſume in his Lord-

ſhip's

Murray.

ſhip's houſe; ſo that nothing remained but the walls, which were ſeen next morning almoſt red-hot from the violence of the flames, preſenting a melancholy and awful ruin to the eyes of the paſſengers. For a fuller account of thoſe dreadful riots, ſee BRITAIN, n° 644. *Encyclopedia*.

So unexpected was this daring outrage on order and government, that it burſt on Lord Mansfield without his being prepared in the ſlighteſt manner to reſiſt it. He eſcaped with his life only, and retired to a place of ſafety, where he remained until the 14th of June, the laſt day of term, when he again took his ſeat in the court of King's Bench. "The reverential ſilence (ſays Mr Douglas) which was obſerved when his Lordſhip reſumed his place on the Bench, was expreſſive of ſentiments of condolence and reſpect, more affecting than the moſt eloquent addreſs the occaſion could have ſuggeſted.

"The amount of that part of Lord Mansfield's loſs which might have been eſtimated, and was capable of a compenſation in money, is known to have been very great. This he had a right to recover againſt the *hundred*. Many others had taken that courſe; but his Lordſhip thought it more conſiſtent with the dignity of his character not to reſort to the indemnification provided by the legiſlature. His ſentiments, on the ſubject of a reparation from the ſtate, were communicated to the Board of Works in a letter, dated 18th July 1780, written in conſequence of an application which they had made to him (as one of the principal ſufferers), purſuant to directions from the treaſury, founded on a vote of the Houſe of Commons, requeſting him to ſtate the nature and amount of his loſs. In that letter, after ſome introductory expreſſions of civility to the ſurveyor general, to whom it was addreſſed, his Lordſhip ſays, 'Beſides what is irreparable, my pecuniary loſs is great. I apprehended no danger, and therefore took no precaution. But how great ſoever that loſs may be, I think it does not become me to claim or expect reparation from the ſtate. I have made up my mind to my misfortune, as I ought, with this conſolation, that it came from thoſe whoſe object manifeſtly was general confuſion and deſtruction at home, in addition to a dangerous and complicated war abroad. If I ſhould lay before you any account or computation of the pecuniary damage I have ſuſtained, it might ſeem a claim or expectation of being indemnified. Therefore you will have no further trouble upon this from, &c.—*Mansfield*."

From this time the luſtre of Lord Mansfield continued to ſhine with unclouded brightneſs until the end of his political life, unleſs his oppoſition to the meaſures of the preſent adminiſtration, at the early period of their appointment, ſhall be thought to detract, in ſome ſmall degree, from his merit. It is certain many of his admirers ſaw, with concern, a connection with the opponents of government at that juncture, ſcarce compatible with the dignity of the chief juſtice of Great Britain. At length infirmities preſſed upon him, and he became unable to attend his duty with the ſame punctuality and aſſiduity with which he had been accuſtomed. It has been ſuppoſed, that he held his office after he was diſabled from executing the duties of it, from a wiſh to ſecure the ſucceſſion of it to a very particular friend. Be this as it may, the chief juſtice continued in his office until the month of June 1788, when he ſent in his reſignation.

From this period the bodily powers of his Lordſhip continued to decline; his mental faculties, however, remained without decay almoſt to the laſt. During this time he was particularly inquiſitive and anxious about the proceedings in France, and felt his ſenſibility, in common with every good man, wounded by the horrible inſtance of democratic infatuation in the murder of the innocent Louis XVI. He lived juſt long enough to expreſs his ſatisfaction at the check given to the French by the Prince of Cobourg in March 1793; on the 20th of which month, after continuing ſome days in a ſtate of inſenſibility, he departed this life, at the age of 88 years.

"In his political oratory (ſays a writer of the preſent times), he was not without a rival; no one had the honour of *ſurpaſſing* him; and let it be remembered, that his competitor was PITT.

"The rhetorician that addreſſed himſelf to Tully in theſe memorable words—*Demoſthenes tibi præripuit ne primus eſſes Orator, tu illi ne ſolus*—anticipated their application to Mansfield and Pitt. If the one poſſeſſed Demoſthenean fire and energy, the other was at leaſt a Cicero. Their oratory differed in ſpecies, but was equal in merit. There was, at leaſt, no ſuperiority on the ſide of Pitt. Mansfield's eloquence was not, indeed, of that daring, bold, declamatory kind, ſo irreſiſtibly powerful in the momentary buſtle of popular aſſemblies; but it was poſſeſſed of that pure and Attic ſpirit, and ſeductive power of perſuaſion, that delights, inſtructs, and eventually triumphs. It has been very beautifully and juſtly compared to a river, that meanders through verdant meads and flowery gardens, reflecting in its cryſtal boſom the varied objects that adorn its banks, and refreſhing the country through which it flows.

"To illuſtrate his oratory by example, would require voluminous tranſcripts from the records of Parliament; and it is unneceſſary, as we can appeal to living recollection.

"Having added weight and dignity to the offices of attorney and ſolicitor general, his reputation as a ſpeaker, a lawyer, and a politician, elevated him to the peerage, and the exalted poſt of chief juſtice of England. He aſcended to the dignities of ſtate by rapid ſtrides: they were not beſtowed by the caprice of party favour or affection. They were (as was ſaid of Pliny) liberal diſpenſations of power upon an object that knew how to add new luſtre to that power, by the rational exertion of his own.

"Here we can ſpeak of this great man within our own recollection; and however party prejudices may adopt their different favourites, and each contend in detracting from the merit of the other, it is, we believe, generally underſtood, that precedence is allowed the Earl of Mansfield, as the firſt magiſtrate that ever ſo pre-eminently graced that important ſtation. The wiſdom of his deciſions, and unbiaſſed tenor of his public conduct, will be held in veneration by the ſages of the law, as long as the ſpirit of the conſtitution, and juſt notions of equity, continue to have exiſtence. No man has ever, in an equal degree, poſſeſſed that wonderful ſagacity in diſcovering chicanery and artifice, and ſeparating fallacy from truth, and ſophiſtry from argument, ſo as to hit the exact equity of the caſe. He ſuffered not juſtice to be ſtrangled in the nets of form.

"His memory was aſtoniſhing—he never took notes, or, if he did, ſeldom or ever conſulted them." His references to expreſſions which fell from him in the courſe of the debate, or his quotations from books, were ſo faithful, that they might have been ſaid to have been repeated *verbatim*. The purpoſes to which he employed theſe amazing talents were ſtill more extraordinary: if it was the weak part of his opponent's arguments that he referred to, he was ſure to expoſe its fallacy, weakneſs, or abſurdity, in the moſt poignant ſatire, or hold it up in the moſt ridiculous point of view. If, on the contrary, it were a point on which his adverſaries laid their chief ſtreſs, he ſtated the words correctly; collected their obvious meaning, conſidered the force of the ſeveral arguments that had or might have been raiſed upon them, with a preciſion that would induce an auditor almoſt to ſuppoſe that he had previouſly conſidered the whole, and that his ſpeech was the reſult of much previous ſtudy.

"It may be ſaid of Mansfield as of Virgil, that if he had any faults, they might be conſidered in the ſame manner with thoſe of ſome eminent fixed ſtar, which, if they exiſt at all, are above the reach of human obſervation. The luminous æther of his life was not obſcured by any ſhade dark enough to be denominated a defect. On account of his deſcent, local prejudices and propenſities were imputed to him, and his conduct, on that account, examined with a microſcopic eye; but the optic through which it was viewed poſſeſſed a party tinge, equally odious and deceptive.

"His political principles were ever conſiſtent; and to preſerve conſiſtency in ſuch ſtations and in ſuch times as occupied the life of Mansfield, conſtitutes an ordeal ſtrongly impreſſive of virtue. It has been ſaid that he wanted ſpirit. Is the uniform oppoſition of popular opinion, and apparently the contempt of it, any proof of the aſſertion? His ſpeech and conduct in the affair of Wilkes's outlawry, when popular prejudice ran in torrents, illuſtrate each other. He deſpiſed (to borrow an expreſſion of his own) that muſhroom popularity that is raiſed without merit, and loſt without a crime. He diſdained being the ſlave of popular impulſe, or to acknowledge the ſhouts of a mob for the trumpet of fame."

He had a mind too great to be aſhamed of revering the ordinances of religion; and as, after the moſt impartial inquiry, he was a firm believer of the truth and importance of Chriſtianity, he frequented the church regularly, and received the holy ſacrament on the higher feſtivals. Mr Holliday has publiſhed a ſermon, which he ſays was dictated by Lord Mansfield to his friend biſhop Johnſon, and preached by that prelate before the Houſe of Lords. It is a very ſerious and appropriate diſcourſe; but judging upon internal evidence, we ſhould not have ſuppoſed it the compoſition of the eloquent and argumentative chief juſtice of England. His Lordſhip's will, which was written with his own hand, upon little more than half a ſheet of paper, begins with the following elegant and pious paragraph, with which we ſhall conclude this ſketch of his character:

"When it ſhall pleaſe Almighty God to call me to that ſtate, to which, of all I now enjoy I can carry only the ſatisfaction of my own conſcience, and a full reliance upon his mercy through Jeſus Chriſt, I deſire that my body may be interred as privately as may be: and out of reſpect for the place of my early education, I ſhould wiſh it to be in Weſtminſter Abbey." It was interred in Weſtminſter Abbey, in the ſame vault with the Counteſs (who had died April 10. 1784), between the late Earl of Chatham and Lord Robert Manners.

MUSEUM, in the language of the preſent day, is a building in which are depoſited ſpecimens of every object that is in any degree curious, whether ſuch objects be natural or artificial. What the word *muſeum* expreſſed originally, has been told under that title in the *Encyclopædia*.

A complete muſeum contains collections of preſerved beaſts, birds, fiſhes, reptiles, &c.; models of machines; rare manuſcripts; and indeed ſpecimens of every thing neceſſary to illuſtrate phyſical ſcience, to improve art, to aid the antiquarian in his reſearches, and to exhibit the manners and cuſtoms of men in diſtant ages and nations. As natural objects of uncommon ſize or beauty, and other rare productions, were, in the earlieſt periods, conſecrated to the gods, the temples were, of courſe, the firſt repoſitories of ſuch collections, or, in other words, the firſt *Muſeums*. This, we think, has been completely proved by Profeſſor Beckmann *.

"When Hanno (ſays he) returned from his diſtant voyages, he brought with him to Carthage two ſkins of the hairy women whom he found on the Gorgades iſlands, and depoſited them as a memorial in the temple of Juno, where they continued till the deſtruction of the city. The horns of a Scythian animal, in which the Stygian water that deſtroyed every other veſſel could be contained, were ſent by Alexander as a curioſity to the temple of Delphi, where they were ſuſpended, with an inſcription, which has been preſerved by Ælian. The monſtrous horns of the wild bulls which had occaſioned ſo much devaſtation in Macedonia, were, by order of King Philip, hung up in the temple of Hercules. The unnaturally formed ſhoulder bones of Pelops were depoſited in the temple of Elis. The horns of the ſo called Indian ants were ſhewn in the temple of Hercules at Erythræ; and the crocodile found in attempting to diſcover the ſources of the Nile was preſerved in the temple of Iſis at Cæſarea. A large piece of the root of the cinnamon tree was kept in a golden veſſel in one of the temples at Rome, where it was examined by Pliny. The ſkin of that monſter which the Roman army in Africa attacked and deſtroyed, and which probably was a crocodile, an animal common in that country, but never ſeen by the Romans before the Punic war, was, by Regulus, ſent to Rome, and hung up in one of the temples, where it remained till the time of the Numantine war (A). In the temple of Juno, in the iſland of Melita, there were a pair of elephants teeth of extraordinary ſize, which were carried away by Maſiniſſa's admiral, and tranſmitted to that prince, who, though he ſet a high value upon them, ſent them again back, becauſe he heard they had been taken from a temple. The head of a baſiliſc was exhibited in one of the temples of Diana; and the bones of that ſea monſter, probably a whale, to which Andromeda was expoſed, were preſerved at Joppa, and afterwards brought to

* *Inventions*, vol. ii. p. 44.

(A) We think, with the tranſlator of Beckmann's Hiſtory, that this animal was not the crocodile, but the *Boa conſtrictor*. See Boa and Serpent, *Encycl.*

Rome. In the time of Pauſanias, the head of the celebrated Calydonian boar was ſhewn in one of the temples of Greece; but it was then deſtitute of briſtles, and had ſuffered conſiderably by the hand of time. The monſtrous tuſks of this animal were brought to Rome, after the defeat of Anthony, by the Emperor Auguſtus, who cauſed them to be ſuſpended in the temple of Bacchus. Apollonius tells us, that he ſaw in India ſome of thoſe nuts which in Greece were preſerved in the temples as curioſities."

Though theſe curioſities were preſerved in the temples for purpoſes very different from thoſe for which our collections are made, there can be no doubt but that they contributed to promote the knowledge of natural hiſtory. If it be true, as Pliny and Strabo inform us, that Hippocrates availed himſelf of the accounts which were hung up in the temple of Æſculapius of different diſeaſes, and of the medicines and mode of treatment by which they were cured; it will eaſily be believed, that the natural hiſtorians availed themſelves, in a ſimilar manner, of the various rare objects which were preſerved in the temples of the other gods. This, we ſee, Pliny actually did.

Suetonius informs us, that Auguſtus had, in his palace, a collection of natural curioſities; and it is well known that Alexander gave orders to all huntſmen, bird-catchers, fiſhermen, and others, to ſend to Ariſtotle whatever rare animals they could procure. M. Beckmann ſeems to be of opinion, that the firſt private muſeum was formed by Apuleius, who, next to Ariſtotle and his ſcholar Theophraſtus, certainly examined natural objects with the greateſt ardour and judgment; who cauſed animals of every kind, and particularly fiſh, to be brought to him either dead or alive, in order to deſcribe their external and internal parts, their number and ſituation, and to determine their characteriſing marks, and eſtabliſh their real names; who undertook diſtant journeys to become acquainted with the ſecrets of nature; and who, on the Getulian mountains, collected petrefactions, which he conſidered as the effects of Deucalion's flood.

The principal cauſe why collections of natural curioſities were ſcarce in ancient times, muſt have been the ignorance of naturaliſts in regard to the proper means of preſerving ſuch bodies as ſoon ſpoil or corrupt. Some methods were indeed known and practiſed, but they were all defective and inferior to that by ſpirit of wine, which prevents putrefaction, and which, by its perfect tranſparency, permits the objects which are covered by it to be at all times viewed and examined. Theſe methods were the ſame as thoſe employed to preſerve proviſions, or the bodies of great men deceaſed. They were put into ſalt brine or honey, or were covered over with wax. Thus the hippopotamus, deſcribed by Columna, was ſent to him from Egypt preſerved in ſalt. The body of Ageſipolis King of Sparta, who died in Macedonia, was ſent home in honey; the celebrated purple dye of the ancients was preſerved freſh for many years by the ſame means; and at this day, when the Orientals are deſirous of tranſporting fiſh to any diſtance, they cover them over with wax.

In thoſe centuries which are uſually called the middle ages, the Profeſſor finds no traces of what can be called a muſeum, except in the treaſuries of emperors, kings, and princes, where, beſides articles of great value, curioſities of art, antiquities, and relics, one ſometimes found ſcarce and ſingular foreign animals, which were dried and preſerved. Such objects were to be ſeen in the old treaſury at Vienna; and in that of St Denis was exhibited the claw of a griffin, ſent by a king of Perſia to Charlemagne; the teeth of the hippopotamus, and other things of the like kind. In theſe collections, the number of the rarities always increaſed in proportion as a taſte for natural hiſtory became more prevalent, and as the extenſion of commerce afforded better opportunities for procuring the productions of remote countries. Menageries were eſtabliſhed to add to the magnificence of courts, and the ſtuffed ſkins of rare animals were hung up as memorials of their having exiſted. Public libraries alſo were made receptacles for ſuch natural curioſities as were from time to time preſented to them; and as in univerſities the faculty of medicine had a hall appropriated for the diſſection of human bodies, curioſities from the animal kingdom were collected there alſo by degrees; and it is probable that the profeſſors of anatomy firſt made attempts to preſerve different parts of animals in ſpirit of wine, as they were obliged to keep them by them for the uſe of their ſcholars; and becauſe in old times dead bodies were not given up to them as at preſent, and were more difficult to be obtained. Private collections appear for the firſt time in the 16th century; and there is no doubt (ſays our author) that they were formed by every learned man who at that period applied to the ſtudy of natural hiſtory.

MUSHROOM, a fungus, of which ſome of the principal ſpecies have been deſcribed in the *Encyclopædia* under the generic name AGARICUS. There is, however, one ſpecies not mentioned there—the *Boletus hirſutus* of Bulliard, which is certainly worthy of notice, ſince one of the French chemiſts has lately extracted from it a bright, ſhining, and very durable yellow dye. This pretty large muſhroom grows commonly on walnut and apple-trees. Its colouring-matter is contained in abundance, not only in the tubular part, but alſo in the parenchyma of the body of the muſhroom. In order to extract it, the muſhroom is pounded in a mortar, and the liquor thence obtained is boiled for a quarter of an hour in water. An ounce of liquor is ſufficient to communicate colouring-matter to ſix pounds of water. When the liquor has been ſtrained, the ſtuff to be dyed is put into it, and boiled for a quarter of an hour. All kinds of ſtuff receive this colour and retain it; but on linen and cotton it is leſs bright. This colour may be modified, in a very agreeable manner, by the effect of mordants.

The proceſs ſucceeded beſt on ſilk. When this ſubſtance, after being dyed, is made to paſs through a bath of ſoft ſoap, it acquires a ſhining golden-yellow colour, which has a perfect reſemblance to the yellow of that ſilk employed to imitate embroidery in gold, and which has hitherto been brought from China and ſold at a dear rate, as the method of dyeing it is unknown in Europe. The yellow colour extracted from this muſhroom may be employed alſo with advantage for painting in water-colours as well as in oil.

MUTSUDDIES, in Bengal, writers, accountants, officers of government.

MUZCOORET, allowances to zemindars in land or money. See ZEMINDAR, *Suppl*.

N.

NABOB, or NOWAB, a title of courteſy given in India to Mahomedans high in ſtation, particularly provincial governors.

THE SUN's NADIR, is the axis of the cone projected by the ſhadow of the earth: ſo called, becauſe that axis being prolonged, gives a point in the ecliptic diametrically oppoſite to the ſun.

NAIB, a deputy.

NAKED, in architecture, as the naked of a wall, &c. is the ſurface, or plane, from whence the projectures ariſe; or which ſerves as a ground to the projectures.

NANCOWRY, or SOURY, as it is ſometimes called, is one of the Nicobar iſles, and ſituated nearly in the centre of the cluſter (See NICOBAR, *Encycl.*). Its length may be about eight miles, and its breadth nearly equal. The iſland of Comerty, which is near it, is more extenſive, but does not perhaps contain more ſolid land, being excavated by a very large bay from the ſea. The ſpace between theſe two iſlands forms a capacious and excellent harbour, the eaſtern entrance of which is ſheltered by another iſland, called Trikut, lying at the diſtance of about a league. The inlet from the weſt is narrow, but ſufficiently deep to admit the largeſt ſhips when the wind is fair.

The Danes have long maintained a ſmall ſettlement at this place, which ſtands on the northern-moſt point of Nancowry, within the harbour. A ſerjeant and three or four ſoldiers, a few black ſlaves, and two ruſty old pieces of ordnance, compoſe the whole of their eſtabliſhment. They have here two houſes; one of which, built entirely of wood, is their habitation; the other, formerly inhabited by their miſſionaries, ſerves now for a ſtorehouſe.

Theſe iſlands are in general woody, but contain likewiſe ſome portions of clear land. From the ſummits of their hills the proſpects are often beautiful and romantic. The ſoil is rich, and probably capable of producing all the various fruits and vegetables common to hot climates. The natural productions of this kind, which moſtly abound, are cocoa nuts, *papias*, plantains, limes, tamarinds, beetle-nuts, and the *melóri*, a ſpecies of breadfruit; yams, and other roots are cultivated and thrive; but rice is here unknown. The *mangoſtain*-tree, whoſe fruit is ſo juſtly extolled, grows wild; and pine-apples of a delicious flavour are found in the woods.

Of all the Nicobar iſles Nancowry and Comerty are ſaid to be the beſt peopled; the population of both being ſuppoſed to amount to eight hundred. The natives of Nancowry and of the Nicobar iſlands in general, live in villages on the ſea-ſhore, and never erect their habitations inland (A). Their houſes are of a circular form, and are covered with elliptical domes, thatched with graſs and the leaves of cocoa nut. They are raiſed upon piles to the height of ſix or eight feet above the ground; the floor and ſides are laid with planks, and the aſcent is by a ladder. In thoſe bays or inlets which are ſheltered from the ſurf, they erect them ſometimes ſo near the margin of the water as to admit the tide to flow under, and waſh away the ordure from below.

In front of their villages, and a little advanced in the water, they plant beacons of a great height, which they adorn with tufts made of graſs, or the bark of ſome tree. Theſe objects are diſcernible at a great diſtance, and are intended probably for landmarks; their houſes, which are overſhadowed by thick groves of cocoa-nut trees, ſeldom being viſible from afar.

The Nicobareans, though indolent, are in general robuſt and well-limbed. Their features are ſomewhat like the Malays, and their colour is nearly ſimilar. The women are much inferior in ſtature to the men, but more active in all domeſtic affairs. Contrary to the cuſtom of other nations, the women ſhave the hair of their heads, or keep it cloſe cropt, which gives them an uncouth appearance, in the eyes of ſtrangers at leaſt.

The inhabitants of Nancowry perform, every year, a very extraordinary ceremony in honour of the dead. It is thus deſcribed by Lieutenant Colebrooke:

" On the anniverſary of this feſtival, if it can be ſo called, their houſes are decorated with garlands of flowers, fruits, and branches of trees. The people of each village aſſemble, dreſt in their beſt attire, at the principal houſe in the place, where they ſpend the day in a convivial manner; the men, ſitting apart from the women, ſmoke tobacco, and intoxicate themſelves; while the latter are nurſing their children, and employed in preparations for the mournful buſineſs of the night. At a certain hour of the afternoon, announced by ſtriking the *Goung*, the women ſet up the moſt diſmal howls and lamentations, which they continue without intermiſſion till about ſun-ſet; when the whole party get up, and walk in proceſſion to the burying-ground. Arrived at the place, they form a circle around one of the graves, when a ſtake, planted exactly over the head of the corpſe, is pulled up. The woman who is neareſt of kin to the deceaſed, ſteps out from the crowd, digs up the ſkull, and draws it up with her hands. At ſight of the bones, her ſtrength ſeems to fail her; ſhe ſhrieks, ſhe ſobs; and tears of anguiſh abundantly fall on the mouldering object of her pious care. She clears it from the earth, ſcrapes off the feſtering fleſh, and laves it plentifully with the milk of freſh cocoa-nuts, ſupplied by the byſtanders; after which ſhe rubs it over with an infuſion of ſaffron, and wraps it carefully in a piece of new cloth. It is then depoſited again in the earth, and covered up; the ſtake is replanted, and hung with the various trappings and imple-

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(A) The great Nicobar iſland is perhaps an exception, where, it is ſaid, a race of men exiſts, who are totally different in their colour and manners. They are conſidered as the *Aborigines* of the country. They live in the interior parts among the mountains, and commit frequent depredations on the peaceable inhabitants of the coaſts.

implements belonging to the deceaſed. They proceed then to the other graves; and the whole night is ſpent in repetitions of theſe diſmal and diſguſtful rites.

"On the morning following, the ceremony is concluded by an offering of many fat ſwine; when the ſacrifice made to the dead affords an ample feaſt to the living: they beſmear themſelves with the blood of the ſlaughtered hogs, and ſome, more voracious than others, eat the fleſh raw. They have various ways, however, of dreſſing their meat, but always eat it without ſalt. A kind of paſte made of the *melóri*, ſerves them for bread; and they finiſh their repaſt with copious potations of *taury*, an inebriating liquor."

The Nicobareans are hoſpitable and honeſt, and are remarkable for a ſtrict obſervance of truth, and for punctuality in adhering to their engagements. Such crimes as theft, robbery, and murder, are unknown in theſe iſlands; but they do not want ſpirit to revenge their injuries, and will fight reſolutely, and ſlay their enemies, if attacked or unjuſtly dealt with. Their only vice, if this failing can be ſo called, is inebriation; but in their cups they are generally jovial and good-humoured. It ſometimes, however, happens at their feaſts, that the men of different villages fall out; and the quarrel immediately becomes general. In theſe caſes they terminate their differences in a pitched battle; where the only weapons uſed are long ſticks, of a hard and knotty wood. With theſe they drub one another moſt heartily, till, no longer able to endure the conflict, they mutually put a ſtop to the combat, and all get drunk again.

NANKAR, ancient allowance to zemindars in land or money.

NANKEEN, or NAN-KING, is a well-known cotton ſtuff, which derives its name from the ancient capital of China (See NAN-KING, *Encycl.*). It is, however, according to Van Braam, manufactured at a great diſtance from that city, in the diſtrict of *Fong-kiang-fou*, ſituated in the ſouth-eaſt of the province of *Kiang-nam* upon the ſea-ſhore. The colour of nankeen is natural, the down of which it is made being of the ſame yellow tinge with the cloth. The colour, as well as ſuperior quality of this cotton, ſeems to be derived from the ſoil; for it is ſaid that the ſeeds of the nankeen cotton degenerate in both particulars when tranſplanted to another province, however little different in its climate. The common opinion, that the colour of the ſtuff is given by a dye, occaſioned an order from Europe, ſome years ago, to dye the pieces of nankeen of a deeper colour than they had at that period; and the reaſon of their being then paler than formerly is as follows:

Shortly after the Americans began to trade with China, the demand increaſed to nearly double the quantity it was poſſible to furniſh. To ſupply this deficiency, the manufacturers mixed common white cotton with the brown; this gave it a pale caſt, which was immediately remarked; and for this lighter kind no purchaſer could be found, till the other was exhauſted. As the conſumption is grown leſs during the laſt three years, the mixture of cotton is no longer neceſſary, and nankeen is become what it was before. By keeping them two or three years, it even appears that they have the property of growing darker. This kind of ſtuff muſt be acknowledged to be the ſtrongeſt yet known. Many perſons have found that clothes made of it will laſt three or four years, although for ever in the waſh. This it is that makes them the favourite wear for breeches and waiſtcoats both in Europe and America. The white nankeen is of the ſame quality, and is made of white cotton as good as the brown, and which alſo grows in Kiang-nam.

NAPLES-YELLOW, called alſo *Neapolitan earth*, in Italian *Giallolino*, and in French *Jaune de Naples*, is a beautiful pigment, concerning which we have much information from the indefatigable Beckmann. "It has (ſays he) the appearance of an earth, is of a pale orange-yellow colour, ponderous, granulated, exceedingly friable, does not effloreſce, nor become moiſt when expoſed to the air, but when applied to the tongue ſeems to adhere to it. When reduced to a fine powder, it remains for ſome time ſuſpended in water, but ſoon depoſits itſelf at the bottom in the form of a ſlime. When boiled with water, the water, at leaſt ſometimes, is obſerved to have a ſomewhat ſaline taſte. It does not efferveſce with acids, but is in part diſſolved by aqua regia (nitro-muriatic acid). In the fire it emits no ſulphureous vapour, is difficult to be fuſed, and by that operation undergoes no material change, only that its colour becomes ſomewhat redder. When fuſed with colourleſs glaſs, it gives it a milk-white colour, a ſure proof that it contains no iron; and, with inflammable ſubſtances, there is obtained from it a regulus which has the appearance of a mixture of lead and antimony.

"This article is brought from Naples for the moſt part in the form of an earthy cruſt about three or four lines in thickneſs, and it ſometimes retains the form of the veſſel in which it has hardened. It can be procured alſo as a fine powder, as the colourmen keep it ſometimes ready pounded for uſe."

About the nature of the ſubſtance called Naples yellow there has been much diverſity of opinion. Moſt of thoſe who have written about it, conſider it as originating from fire, and as a volcanic production of Mount Veſuvius or Mount Ætna; others have pronounced it to be a natural ochre. Guettard thought it rather a kind of bole; but Pott approached neareſt the truth, by aſſerting it to be an artificial preparation *. Fougeroux is entitled to the merit of having proved this, and of having ſhewn the poſſibility of preparing it. According to his experiments, Naples yellow will be obtained, if you boil for ſeven or eight hours, firſt over a ſlow and then over a ſtrong fire, a mixture finely pulveriſed of twelve parts of pure white lead, one part of alum, one part of ſal ammoniac, and three parts of diaphoretic antimony † (white oxyd of antimony by nitre). But before Fougeroux, who may have obtained an account of the proceſs during his travels through Italy, a more certain proceſs was publiſhed in the year 1758, by Giambattiſta Paſſeri, in his intereſting work on the painting of earthen-ware ‡. The articles to be employed, according to this author, are, "one pound of antimony, a pound and a half of lead, one ounce of *alume di feccia*, and the ſame quantity of common ſalt." I am inclined (ſays M. Beckmann) to think that this receipt was not unknown to Fougeroux, and that he conſidered *alume di feccia* to be alum. Profeſſor Leonhardi, a man of very ſound learning, has tranſlated this expreſſion by the word alum. I will, however, freely confeſs, that I conſider *alume di feccia* not to mean alum, but ſalt of tartar, or potaſh. Paſſeri

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* *Lithogeognoſie*, v. ii. p. 15.

† *Mem. of the Acad. of Sciences*, 1766.

‡ *In Nuova raccolta d'opuſculi ſcientifici*, t. iv.

Naples, Nardus.

ſeri ſays, that the proportions may be varied different ways; and he gives ſix other receipts, in which he does not mention *alume di feccia*, but only *feccia*; and this word certainly means *weinheſen* or wineſtone (tartar). Profeſſor Leonhardi himſelf ſeems to confirm this opinion, by ſaying, that Vairo, profeſſor of chemiſtry at Naples, has tranſlated "the aſhes of wine lees" (*cineres inſectorii*) by the words *alume di feccia*.

After Fougeroux's paper was printed, De la Lande publiſhed a receipt which he had received from the well-known prince San Severo, and in which lead and antimony only are employed; but no mention is made either of alum, tartar, or any other ſalt. This receipt is as follows:

Take lead well calcined and ſifted, with a third part of its weight of antimony pounded and ſifted alſo. Mix theſe ſubſtances well together, and ſift them again through a piece of ſilk. Then take large flat earthen diſhes, not varniſhed, cover them with white paper, and ſpread out the powder upon them to the depth of about two inches. Place theſe diſhes in a potter's furnace, but only at the top, that they may not be expoſed to too violent a heat. The reverberation of the flame will be ſufficient. The diſhes may be taken out at the ſame time as the earthen-ware, and the ſubſtance will then be found hard, and of a yellow colour. It is then pounded on a piece of marble with water, and afterwards dried for uſe.

The enamel-painters in Germany prepare a yellow glazing, not very different from the real Naples yellow, by a preſcription, according to which, "one pound of antimony, ſix ounces of red lead, and two ounces of white ſand, are to be fuſed together. The produce, which appears quite black, is to be pounded, and then fuſed again; and this proceſs is to be repeated till the whole maſs becomes thoroughly yellow. Half a pound of this maſs is to be mixed with two ounces of red lead, and afterwards fuſed; and by this tedious proceſs an orange-yellow pigment will be obtained."

All artiſts who ſpeak of the uſe of Naples yellow, give cautions againſt applying iron to it, as the colour by theſe means becomes greeniſh, or at leaſt dirty. For this reaſon, it muſt be pounded on a ſtone, and ſcraped together with an ivory ſpatula. It is employed chiefly in oil painting, becauſe the colour is ſofter, brighter, and richer than that of ochre, yellow lead, or orpiment, and becauſe it far exceeds theſe pigments in durability. It is employed in particular when the yellow ought to have the appearance of gold, and in this reſpect it may be prepared with gum water, and uſed as a water colour. A ſtill greater advantage of it is, that it is proper for enamel painting, and on that account may be employed on porcelain or earthen ware (A). Profeſſor Beckmann, however, recommends to artiſts to examine whether the oxyd prepared from wolfram, by boiling in the muriatic acid, which has a beautiful yellow colour, might not be uſed in the ſame manner as Naples yellow.

NARDUS. Under this generic term we have, in the *Encyclopædia*, given, from the *Philoſophical Tranſactions*, a deſcription of the plant or graſs which Dr Blane conſiders as the ſpikenard of the ancients. It is

Nardus, Nares.

our duty, in this place, to inform our readers, that Sir William Jones, in the 2d and 4th volumes of the *Aſiatic Reſearches*, ſeems to have completely proved that the ſpikenard of Dioſcorides and Galen, or *Nardus Indica*, was a very different plant from the Andropogon of Dr Blane, and that it grows in a country far diſtant from *Mackran*. The proofs brought by the illuſtrious preſident of the Aſiatic Society, in ſupport of his own opinion, are too numerous and circumſtantial to be introduced into ſuch a work as this. We ſhall therefore only give one of them; which though, when ſeparated from the reſt, it loſes much of its force, muſt be allowed, even ſingly, to have great weight.

The true Indian ſpikenard is confeſſedly called by the Arabs *Sumbulu'l Hind*; for ſo they tranſlate the name of it in Dioſcorides. Now (ſays Sir William) I put a fair and plain queſtion ſeverally to three or four Muſſulman phyſicians: "What is the Indian name of the plant which the Arabs call *Sumbulu'l Hind?*" They all anſwered, but ſome with more readineſs than others, *Jétámansí*. After a pretty long interval, I ſhewed them the ſpikes (as they are called) of *Jútámansí*, and aſked, what was the Arabic name of that Indian drug? They all anſwered readily, *Sumbulu'l Hind*. The ſame evidence may be obtained in this country by any other European who ſeeks it; and if among twelve native phyſicians, verſed in Arabian and Indian philology, a ſingle man ſhould, after due conſideration, give different anſwers, I will cheerfully ſubmit to the Roman judgment of *non liquet*. But the *Jútámansí* * evidently belongs to the natural order which Linnæus calls *aggregate*; with the following *characters*:

* Plate XXX.

Calyx, ſcarce any; *margin*, hardly diſcernible. *Corolla*, one petal; *tube* ſomewhat gibbous; *border* five cleft. *Stamina*, three *Anthers*. *Piſtula*, *Germ* beneath; one *Style* erect. *Seed*, ſolitary, crowned with a pappus. *Root*, fibrous. *Leaves*, hearted, fourfold; *radical* leaves petioled.

It appears therefore (continues the learned author) to be the Protean plant Valerian, a ſiſter of the Mountain and Celtick Nard, and of a ſpecies which I ſhould deſcribe in the Linnean ſtyle, *Valeriana Játámansí floribus triandris, foliis cordatis quaternis, radicalibus petiolatis*. The radical leaves, riſing from the ground, and enfolding the young ſtem, are plucked up with a part of the root, and being dried in the ſun or by an artificial heat, are ſold as a drug, which, from its appearance, has been called ſpikenard. The Játámansí is a native of the moſt remote and hilly parts of India, ſuch as NE'PA'L, Marang Butan, near which Ptolemy fixes the native ſoil of the *Nardus Indica*. It grows erect above the ſurface of the ground, reſembling an ear of green wheat; and when recent, it has a faint odour, which is greatly increaſed by the ſimple proceſs of drying it.

NARES (JAMES), doctor of muſic, an eminent compoſer and teacher in that ſcience, under whom ſome of the firſt muſicians of the preſent day received the whole or part of their education, was the ſon of Mr Nares, who was, for many years, ſteward to Montague

Biog. Dict. new edit.

(A) In the Memoirs of the Academy of Sciences for 1767, Fougeroux has proved that the giallolino prepared by him produced on porcelain a much more beautiful colour than the Naples yellow ſold in the ſhops.

and Willoughby, earls of Abingdon. He was born, as well as his brother, the late Mr Juſtice Nares, at Stanwell in Middleſex; the former in 1715, the latter in 1716. His muſical education he commenced under Mr Gates, then maſter of the royal choriſters; and completed it under the celebrated Dr Pepuſch. Thus prepared, he officiated, for ſome time, as deputy to Mr Pigott, organiſt of Windſor; but on the reſignation of Mr Saliſbury, organiſt of York, in 1734, was choſen to ſucceed him, being then only nineteen. It is related, on undoubted authority, that, when the old muſician firſt ſaw his intended ſucceſſor, he ſaid, rather angrily, "What! is that child to ſucceed me?" which being mentioned to the organiſt-elect, he took an early opportunity, on a difficult ſervice being appointed, to play it throughout half a note below the pitch, which brought it into a key with ſeven ſharps; and went through it without the ſlighteſt error. Being aſked why he did ſo? he ſaid, that "he only wiſhed to ſhew Mr Saliſbury what a child could do." His knowledge in all branches of his profeſſion was equal to his practical ſkill in this inſtance; and, during his reſidence at York, where he was abundantly employed as a teacher, and where he married, Mr Nares, by his good conduct, as well as profeſſional merit, obtained many powerful friends. Among the foremoſt of theſe was Dr Fontayne, the reſpectable and venerable dean of York; who, when Dr Green died, towards the latter end of 1755, exerted his intereſt ſo ſucceſsfully, that he obtained for him the united places of organiſt and compoſer to his majeſty. He removed therefore to London in the beginning of 1756; and, about the ſame time, was created doctor in muſic at Cambridge.

On the reſignation of Mr Gates, in 1757, Dr Nares obtained alſo the place of maſter of the choriſters; which having been, for a long time, without increaſe, notwithſtanding the increaſe of expences attending it, was, by royal favour, augmented about 1775, firſt with the ſalary of the violiſt; and, on the revival of that place for Mr Croſdill, in 1777, with that of lutaniſt, which was annexed to it for ever. It was in this ſituation that Dr Nares ſuperintended the education of many pupils, who have ſince become famous; particularly Dr Arnold, who, though with him only for a ſhort time, was highly diſtinguiſhed by him for talents and application. The anthems and ſervices which Dr Nares produced, as compoſer to the royal chapel, were very numerous; many of them have ſince been printed, and many which exiſt only in manuſcript ſtill continue to be performed in the choirs with much effect. Having been originally a muſician rather by accident than choice, with very ſtrong talents and propenſities alſo for literature, Dr Nares was particularly attentive to expreſs the ſenſe of the words he undertook to ſet; and was the firſt who attempted to compoſe the Te Deum for the choir-ſervice, in ſuch a manner as to ſet off the ſentiments it contains to advantage. Before his time, it had been ſet rather to a regular ſtrain of chaunt than to any expreſſive melodies. The merits of Dr Nares were not overlooked by his royal patrons, whom he had occaſionally the honour to attend in private, though not a part of his regular duty. To manifeſt his reſpect and gratitude for them, he compoſed his dramatic ode, entitled The Royal Paſtoral, the words of which were written by Mr Bellamy, author of a book, entitled Ethic Amuſements.

In July 1780, Dr Nares was obliged, by declining health, to reſign the care of the choriſters, in which place he was ſucceeded by Dr Ayrton, his pupil and valued friend. In his ſixty-eighth year, a conſtitution, never robuſt, gave way, and he died on February 10. 1783. Teſtimony has been borne to the merits of Dr Nares by ſeveral writers, but more particularly by Mr Maſon, in his preface to a book of anthems, printed for the uſe of York Cathedral; and in his late Eſſays on Church Muſic, page 138. The late Lord Mornington, ſo well known for muſical talents, frequently conſulted him; and Sir John Hawkins derived advantage from his acquaintance, in the progreſs of his Hiſtory of Muſic. Throughout life, he was not leſs reſpected as a man than admired as a muſician; he had a vivacity that rendered his ſociety always pleaſing; and a generous contempt for every thing baſe, that manifeſted itſelf on all proper occaſions, and very juſtly commanded eſteem.

His printed works are theſe: 1. Eight Sets of Leſſons for the Harpſichord; dedicated to the Right Hon. Willoughby Earl of Abingdon. Printed in 1748; reprinted in 1757. 2. Five Leſſons for the Harpſichord, with a Sonata in ſcore for the Harpſichord or Organ; dedicated to the Right Honourable the Counteſs of Carliſle; publiſhed in 1758 or 1759. 3. A Set of Eaſy Leſſons for the Harpſichord, three in number; with a dedication to the public, ſigned J. N. 4. A Treatiſe on Singing, ſmall ſize. 5. Il Principio; or A regular Introduction to playing on the Harpſichord or Organ. This was the firſt ſet of progreſſive leſſons publiſhed on a regular plan. 6. The Royal Paſtoral, a Dramatic Ode; dedicated to his Royal Highneſs the Prince of Wales; printed in ſcore, with an overture and choruſes. 7. Catches, Canons, and Glees; dedicated to the late Lord Mornington. 8. Six Fugues, with Introductory Voluntaries for the Organ or Harpſichord. 9. A Conciſe and Eaſy Treatiſe on Singing, with a Set of Engliſh Duets for Beginners. A different work from the former ſmall treatiſe. 10. Twenty Anthems, in ſcore, for one, two, three, four, and five Voices. Compoſed for the Uſe of his Majeſty's Chapels Royal, 1778. 11. Six Eaſy Anthems, with a favourite Morning and Evening Service, left for publication at his death, and publiſhed in 1788, with a portrait and a conciſe account of the author. Of theſe compoſitions the following ſhort character is given by an eminent muſician, to whom they are all well known: "The leſſons are compoſed in a maſterly and pleaſing ſtyle; free from thoſe tricks and unmeaning ſucceſſions of ſemitones, to which a good ear and ſound judgment never can be reconciled. The treatiſes on ſinging contain duets compoſed for the uſe of the children of the royal chapels, ſuperior to any thing yet publiſhed; and ſuch as every teacher ought to peruſe. His catches, canons, and glees, are natural and pleaſing; eſpecially the glee to all Lovers of Harmony, which gained the prize medal at the catch-club in 1770. The Royal Paſtoral is compoſed throughout in a very maſterly manner; particularly the choruſes, with which each part concludes. This ode, containing 108 pages, was written, and all the vocal and inſtrumental parts tranſcribed for performing, within twelve days. The ſix fugues, with introductory voluntaries for the organ, contain the ſtrongeſt proofs of ingenuity and judgement; few, if any, have ever been written that can be preferred to them. In both ſets of the anthems, the ſame characteriſtics appear; and the ſervice of the latter very juſtly acquired the title of *favourite;* nor can there be any doubt that the works of this author will be admired as long as a taſte for muſic ſhall ſubſiſt."

NAVIGATORS ISLANDS, an archipelago in the South Sea, diſcovered by Bougainville, who gave to them that name, becauſe the natives do not paſs between the different villages, which are all built in creeks and bays, but in their canoes. The Navigators Iſlands are ten in number; namely, *Opoun*, *Leoné*, *Fanfoué*, MAOUANA, *Oyolava*, *Calinaſſé*, *Pola*, *Shika*, *Oſſamo*, and *Ouera*.

We have already given an account of the ſoil and productions of MAOUANA; and as the other iſlands of this cluſter are equally fertile, we need not go over the ſame ground again. It may be proper, however, to obſerve, that in ſome of them the ſugar-cane was found growing ſpontaneouſly, though its juice contained leſs of the ſaccharine ſubſtance than the ſugar cane of the Weſt Indies, which our voyagers attributed to its growing in a richer ſoil and in the ſhade. According to Perouſe, the Navigators Iſlands are ſituated about the 14th degree of ſouth latitude, and between the 171ſt and 175th degrees of longitude weſt from Paris. In Oyolava the ſmoke was ſeen hovering over a village as over a large European town; and the number of canoes which from that iſland ſurrounded the frigates was immenſe. Theſe are very tickliſh veſſels, and would be abſolutely uſeleſs to any body but ſuch excellent ſwimmers as the iſlanders, who are no more ſurpriſed or uneaſy at their overſetting than we are at the fall of a hat. Taking up the canoe on their ſhoulders, they empty it of water, and then get in again, with the certainty of having the ſame operation to perform a ſecond time in half an hour. Sometimes they join two canoes together by means of a croſs piece of wood, in which they make a ſtep to receive the maſt; and in this way they are leſs liable to be overſet, ſometimes performing a long voyage without any ſuch accident. It is needleſs to add, that theſe canoes are very ſmall, generally containing only five or ſix perſons, though ſome few of them may contain as many as fourteen.

The natives of the Navigators Iſlands are tall and well made. Their uſual height is five feet nine, ten, and eleven inches; but their ſtature is leſs aſtoniſhing than the coloſſal proportions of the different parts of their bodies. "Our curioſity (ſays Perouſe), which often led us to meaſure them, gave them an opportunity of making frequent compariſons of their bodily ſtrength with ours. Theſe compariſons were not to our advantage; and we perhaps owe our miſfortunes (ſee MAOUANA in this *Suppl.*) to the idea of individual ſuperiority reſulting from repeated trials. Their countenances often appeared to expreſs a ſentiment of diſdain, which I hoped to deſtroy, by ordering our arms to be uſed in their preſence: but my end could only have been gained by directing them againſt human victims; for otherwiſe they took the noiſe for ſport, and the trial for a diverſion.

"Among theſe Indians a very ſmall number is below the height indicated above. I have, however, meaſured ſeveral who were only five feet four inches, but theſe are the dwarfs of the country; and although their ſtature reſembles ours, their ſtrong and nervous arms, their broad cheſts, and their legs and thighs, are of a very different proportion.

"The men have the body painted or tatowed, ſo that any one would ſuppoſe them clad, although they go almoſt naked. They have only a girdle of ſea-weeds encircling their loins, which comes down to their knees, and gives them the appearance of the river gods of fabulous hiſtory, whom it is cuſtomary to depict with ruſhes round their waiſt. Their hair is very long. They often twiſt it round their heads, and thus add to their native ferocity of countenance, which always expreſſes either ſurpriſe or anger. The leaſt diſpute between them is followed by blows of ſticks, clubs, or paddles; and often, without doubt, coſts the combatants their lives They are almoſt all covered with ſcars, which can only be the conſequence of their individual quarrels. The ſtature of the women is proportioned to that of the men. They are tall, ſlender, and not without grace; but they loſe, while yet in their prime, thoſe elegant forms, of which nature has not broken the mould among this barbarous race, but of which ſhe appears to leave them in poſſeſſion only for a moment, and with reluctance. Among a great number of women that I had an opportunity of ſeeing, I only obſerved three really pretty. The groſs effrontery of the reſt, the indecency of their motions, and the diſguſting offers which they made of their favours, rendered them fit mothers and wives for the ferocious beings that ſurrounded us." Our author gives the following inſtance of indecent manners, which is, perhaps, without a parallel.

The young and prettieſt females ſoon attracted the attention of ſeveral Frenchmen, who, in ſpite of the Commodore's prohibition, endeavoured to form a connection with them, and were ſucceſsful. The looks of the Europeans expreſſing deſires which were ſoon divined, ſome old women undertook the negociation. The altar was prepared in the handſomeſt hut in the village, all the blinds were let down, and the inquiſitive were excluded. The victim was then laid in the arms of an old man, who exhorted her, during the ceremony, to moderate the expreſſion of her pain; while the matrons ſang and howled: the ceremony being performed in their preſence, and under the auſpices of the old man, who ſerved at once as prieſt and altar. All the women and children in the village were round the houſe, gently lifting up the blinds, and ſeeking to enjoy the ſight through the ſmalleſt crevices in the mats. Whatever former navigators may have ſaid, Perouſe was convinced that, in the Navigators Iſlands at leaſt, the young girls, before they are married, are miſtreſſes of their perſons, and that they are not diſhonoured by their complaiſance. It is even more than probable, that, in marrying they are called to no account concerning their paſt conduct; but he had no doubt that they are obliged to be more reſerved when provided with a huſband.

Theſe people cultivate certain arts with ſucceſs. Under the article MAOUANA mention has been made of the elegant form which they give to their huts. It is not with ſuch folly as is commonly ſuppoſed that they diſdain our inſtruments of iron; for they finiſh their work very neatly with tools made of a very fine and compact ſpecies of baſaltes in the form of an adze. For a few glaſs beads they ſold to Perouſe large three-legged diſhes of a ſingle piece of wood, and ſo well poliſhed that they ſeemed to have been laid over with a coat of the fineſt varniſh. It would take an European workman ſeveral days to produce one of theſe diſhes, which, for want of proper inſtruments, muſt coſt an Indian ſeveral months labour. They ſet, however, ſcarcely any value upon them, becauſe they ſet little upon the time they employ. The fruit trees and nutritious roots that grow ſpontaneouſly around them, inſure to them their ſubſiſtence, as well as that of their hogs, dogs, and fowls; and if they ſometimes ſtoop to work, it is to procure enjoyments rather agreeable than uſeful. They manufacture very fine mats, and ſome paper ſtuffs. Our author remarked two or three of them, whom he took for chiefs, with a piece of cloth tied round their waiſt like a petticoat, inſtead of a girdle of weeds. It is compoſed of real thread, prepared no doubt from ſome filamentous plant like the nettle or flax; and is manufactured without a ſhuttle, the threads being abſolutely laid over one another like thoſe of their mats. This cloth, which has all the ſuppleneſs and ſolidity of ours, is very fit for the ſails of their canoes; and appeared far ſuperior to the paper ſtuff of the Society and Friendly Iſlands, which they manufacture alſo. Their canoes are well conſtructed, and furniſh a good proof of the ſkill with which they work in wood. For a few glaſs beads they gave to the Frenchmen, among other things, a wooden veſſel filled with cocoa-nut oil, exactly of the ſhape of our earthen pots, and ſuch as no European would undertake to faſhion by any other means than a turning lathe. Their ropes are round, and twiſted like watch chains of ribbon: their mats are very fine; but their ſtuffs are inferior to thoſe of the Eaſter and Sandwich Iſlands.

Perouſe derives the natives of thoſe iſlands, whoſe colour, he ſays, nearly reſembles that of the Algerines and other nations on the coaſt of Barbary, from the Malays; and as we do not vouch for the truth of his theory, though we admit it to be ingenious, we ſhall give the reaſoning by which he ſupports it in his own words.

"We did not at firſt diſcover (ſays he) any identity between their language and that of the natives of the Society and Friendly Iſlands, of which we had vocabularies; but a more mature examination convinced us, that they ſpeak a dialect of the ſame language. A fact which tends to prove it, and which confirms the opinion of the Engliſh concerning the origin of theſe people, is, that a young domeſtic, a native of the province of Tagayan in the north of Manilla, underſtood and explained to us the greater part of their words. It is well known that the Tagayan, the Talgal, and the generality of languages ſpoken in the Philippines, are derived from the Malay: a language more diffuſed than were thoſe of the Greeks and Romans, and common to the numerous tribes that inhabit the iſlands of the great Pacific Ocean. It appears to me evident, that all theſe different nations are the progeny of Malay colonies, which, in ſome age extremely remote, conquered the iſlands they inhabit. I ſhould not even wonder, if the Chineſe and Egyptians, whoſe antiquity is ſo much vaunted, were mere moderns in compariſon of the Malays. But however this may be, I am ſatisfied that the aborigines of the Philippine Iſlands, Formoſa, New Guinea, New Britain, the New Hebrides, the Friendly Iſlands, &c. in the ſouthern hemiſphere, and thoſe of the Marianna and Sandwich iſlands in the northern, were that race of woolly headed men ſtill found in the interior of the iſlands of Luconia and Formoſa. They were not to be ſubjugated in New Guinea, New Britain, and the New Hebrides; but being overcome in the more eaſtern iſlands, which were too ſmall to afford them a retreat in the centre, they mixed with the conquering nation. Thence has reſulted a race of very black men, whoſe colour is ſtill ſeveral ſhades deeper than that of certain families of the country, probably becauſe the latter have made it a point of honour to keep their blood unmixed. I was ſtruck with theſe two very diſtinct races in the Iſlands of Navigators, and cannot attribute to them any other origin.

"The deſcendants of the Malays have acquired in thoſe iſlands a degree of vigour and ſtrength, a lofty ſtature, and a Herculean form, which they do not inherit from their forefathers, but which they owe, without doubt, to an abundance of food, to a mild climate, and to the influence of different phyſical cauſes which have been conſtantly acting during a long ſeries of generations. The arts which they perhaps brought with them may have been loſt for want of materials and inſtruments to practiſe them; but the identity of language, like Ariadne's clue, enables the obſerver to follow all the windings of this new labyrinth. The feudal government is alſo preſerved here: that government which little tyrants may regret; which was the diſgrace of Europe for ſeveral centuries; and of which the Gothic remains are ſtill to be found in our laws, and are the medals that atteſt our ancient barbariſm: that government, which is the moſt proper to keep up a ferocity of manners, becauſe the ſmalleſt diſputes occaſion wars of village againſt village, and becauſe wars of this nature are conducted without magnanimity, and without courage. Surpriſes and treachery are employed by turns; and in theſe unfortunate countries, inſtead of generous warriors, nothing is to be found but baſe aſſaſſins (A). The Malays are ſtill the moſt perfidious nation

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(A) This was written under the old government of France by a man who, like other declaimers in the cauſe of liberty, forgot the excellencies, and inſiſted only on the defects of the feudal inſtitutions. Had Perouſe, however, returned to Europe, and witneſſed the *philoſophic* government of his country, he would have perceived, that *liberty* and *equality*, and *the rights of man*, are as well calculated to generate baſe aſſaſſins, as the Gothic remains of that government by which he ſuppoſed Europe to have been ſo long diſgraced. He might even have lived to regret, that his lot was not caſt among the bold and ferocious inhabitants of Maouana; for the treachery and cruelty of theſe people bears no proportion, even in his affecting narrative, to the ſyſtematic cruelty of thoſe who decreed, that the end ſanctifies the means, and that nothing, however atrocious in the eſtimation of antiquated moraliſts, is to be omitted, which contributes to elevate the mean above the noble.

tion of Aſia; and their children have not degenerated, becauſe the ſame cauſes have led to and produced the ſame effects. It may be objected, perhaps, that it muſt have been very difficult for the Malays to make their way from weſt to eaſt, to arrive at theſe different iſlands; but the weſterly winds blow as frequently as the eaſterly in the vicinity of the equator, along a zone of ſeven or eight degrees from north to ſouth, where the wind is ſo variable, that it is hardly more difficult to navigate eaſt than weſt. Beſides, theſe different conqueſts may not have been effected at the ſame time: the people in queſtion may, on the contrary, have ſpread themſelves by little and little, and gradually have introduced that form of government which ſtill exiſts in the peninſula of Malacca, at Java, Sumatra, and at Borneo, as well as in all the other countries ſubject to that barbarous nation."

NAZER, Nazr, Nezer, Nuzzer, Nuzzerana; a preſent from an inferior; fees of office.

NEBULOUS, or Cloudy, a term applied to certain fixed ſtars which ſhew a dim hazy light; being leſs than thoſe of the ſixth magnitude, and therefore ſcarcely viſible to the naked eye, to which at beſt they only appear like little duſky ſpecks or clouds. Through a moderate teleſcope, theſe nebulous ſtars plainly appear to be congeries or cluſters of ſeveral little ſtars.

NECKAR isle, a ſmall barren iſland, or rather rock, diſcovered by Perouſe in the Pacific Ocean. Though its ſterility renders it of no importance in itſelf, its exact ſituation muſt be intereſting to navigators, who are therefore obliged to the French Commodore for having aſcertained its latitude to be 23° 34′ north, and its longitude to be 166° 52′ weſt from Paris. From the ſoundings the *Neckar* ſeemed to be only the top or nucleus of a much more conſiderable iſland, which, probably from being compoſed of a ſoft and diſſoluble ſubſtance, the ſea had gradually waſhed away. In proportion as the frigates left the ſhore, the depth, which at the diſtance of a mile was very little, gradually increaſed, till, at the diſtance of about ten miles, no bottom was found with a line of 150 fathoms; and over the whole of that ſhore the bottom conſiſted of coral and broken ſhells.

NEPAL, a kingdom of India, ſituated to the north-eaſt of the city of Patna, at the diſtance of ten or twelve days journey. Within the diſtance of four days journey from Nepal the road is good in the plains of Hindoſtan, but in the mountains it is bad, narrow, and dangerous. At the foot of the hills the country is called *Teriani*; and there the air is very unwholeſome from the middle of March to the middle of November; and people in their paſſage catch a diſorder called in the language of that country *aul*; which is a putrid fever, and of which the generality of people, who are attacked with it, die in a few days; but on the plains there is no apprehenſion of it. Although the road be very narrow and inconvenient for three or four days at the paſſes of the hills, where it is neceſſary to croſs and recroſs the river more than fifty times, yet, on reaching the interior mountain before you deſcend, you have an agreeable proſpect of the extenſive plain of Nepal, reſembling an amphitheatre covered with populous towns and villages: the circumference of the plain is about 200 miles, a little irregular, and ſurrounded by hills on all ſides, ſo that no perſon can enter or come out of it without paſſing the mountains.

There are three principal cities in the plain, each of which was the capital of an independent kingdom; the principal city of the three is ſituated to the northward of the plain, and is called *Cat'hmandu*: it contains about 18,000 houſes; and this kingdom, from ſouth to north, extends to the diſtance of twelve or thirteen days journey as far as the borders of Tibet, and is almoſt as extenſive from eaſt to weſt. The king of Cat'hmandu has always about 50,000 ſoldiers in his ſervice. The ſecond city to the ſouth-weſt of Cat'hmandu is called *Lelit Pattan*; it contains near 24,000 houſes. The third principal city to the eaſt of Lelit Pattan is called *B'hatgan*: it contains about 12,000 families; and is the metropolis of a diſtrict which extends towards the eaſt to the diſtance of five or ſix days journey; and borders upon another nation, alſo independent, called *Ciratas*, who profeſs no religion. Beſides theſe three principal cities, there are many other large and leſs conſiderable towns or fortreſſes; one of which is *Timi*, and another *Cipoli*, each of which contains about 8000 houſes, and is very populous. All thoſe towns, both great and ſmall, are well built; the houſes are conſtructed of brick, and are three or four ſtories high; their apartments are not lofty; they have doors and windows of wood well worked and arranged with great regularity. The ſtreets of all their towns are paved with brick or ſtone, with a regular declivity to carry off the water. In almoſt every ſtreet of the capital towns there are alſo good wells made of ſtone, from which the water paſſes through ſeveral ſtone canals for the public benefit. In every town there are large ſquare varandas well built, for the accommodation of travellers and the public: theſe varandas are called *Pali*; and there are alſo many of them, as well as wells, in different parts of the country for public uſe. There are alſo, on the outſide of the great towns, ſmall ſquare reſervoirs of water, faced with brick, with a good road to walk upon, and a large flight of ſteps for the convenience of thoſe who chooſe to bathe.

The religion of Nepal is of two kinds: the more ancient is profeſſed by many people who call themſelves *Baryeſu*; they pluck out all the hair from their heads; their dreſs is of coarſe red woollen cloth, and they wear a cap of the ſame: they are conſidered as people of the religious order, and their religion prohibits them from marrying, as it is with the Lamas of Tibet, from which country their religion was originally brought; but in Nepal they do not obſerve this rule, except at their diſcretion. They have large monaſteries, in which every one has a ſeparate apartment or place of abode. They obſerve alſo particular feſtivals, the principal of which is called *Yatra* in their language, and continues a month or longer according to the pleaſure of the king. The ceremony conſiſts in drawing an idol, which at Lelit Pattan is called *Baghero*, in a large and richly ornamented car, covered with gilt copper: round about the idol ſtand the king and the principal Baryeſus; and in this manner the vehicle is almoſt every day drawn thro' ſome one of the ſtreets of the city by the inhabitants, who run about beating and playing upon every kind of inſtrument their country affords, which make an inconceivable noiſe.

The other religion, the more common of the two, is that of the Brahmens, and is the ſame as is followed in Hindoſtan, with the difference that, in the latter country the Hindus being mixed with the Mahommedans, their religion alſo abounds with many prejudices, and is not ſtrictly obſerved; whereas in Nepal, where there are no Muſſelmans (except one Caſhmirian merchant), the Hindu religion is practiſed in its greateſt purity: every day of the month they claſs under its proper name, when certain ſacrifices are to be performed and certain prayers offered up in their temples: the places of worſhip are more in number in their towns than are to be found in the moſt populous and moſt flouriſhing cities of Chriſtendom; many of them are magnificent according to their ideas of architecture, and conſtructed at a very conſiderable expence; ſome of them have four or five ſquare cupolas, and in ſome of the temples two or three of the extreme cupolas, as well as the doors and windows of them, are decorated with gilt copper.

In the city of Lelit Pattan the temple of Baghero is more valuable, on account of the gold, ſilver, and jewels it contains, than even the houſe of the king. Beſides the large temples, there are alſo many ſmall ones, which have ſtairs, by which a ſingle perſon may aſcend, on the outſide all around them; and ſome of thoſe ſmall temples have four ſides, others ſix, with ſmall ſtone or marble pillars poliſhed very ſmooth, with two or three pyramidal ſtories, and all their ornaments well gilt, and neatly worked according to their ideas of taſte. On the outſide of ſome of their temples there are great ſquare pillars of ſingle ſtones from twenty to thirty feet high, upon which they place their idols ſuperbly gilt. The greateſt number of their temples have a good ſtone ſtaircaſe in the middle of the four ſquares, and at the end of each flight of ſtairs there are lines cut out of ſtone on both ſides: around about their temples there are alſo bells, which the people ring on particular occaſions; and when they are at prayers, many cupolas are alſo quite filled with little bells hanging by cords in the inſide about the diſtance of a foot from each other, which make a great noiſe on that quarter where the wind conveys the ſound. There are not only ſuperb temples in their great cities, but alſo within their caſtles.

To the eaſtward of Cat'hmandu, at the diſtance of about two or three miles, there is a place called *Tolu*, by which there flows a ſmall river, the water of which is eſteemed holy, according to their ſuperſtitious ideas, and thither they carry people of high rank, when they are thought to be at the point of death: at this place there is a temple, which is not inferior to the beſt and richeſt in any of the capital cities. They alſo have it on tradition, that at two or three places in Nepal valuable treaſures are concealed under ground: one of thoſe places they believe is Tolu; but no one is permitted to make uſe of them except the king, and that only in caſes of neceſſity. Thoſe treaſures, they ſay, have been accumulated in this manner: When any temple had become very rich from the offerings of the people, it was deſtroyed, and deep vaults dug under ground one above another, in which the gold, ſilver, gilt copper, jewels, and every thing of value, were depoſited. This was found to be actually the caſe when the miſſionary, from whoſe memoir this account of Nepal is taken, was at Cat'hmandu. One of the kings, or pretenders to the crown, who were then at war with each other, being in the utmoſt diſtreſs for want of money to pay his troops, ordered the vaults at Tolu to be opened; and found in the firſt vault more money, beſides ſilver and gold idols, than he had immediate occaſion for.

To the weſtward alſo of the great city of Lelit Pattan, at the diſtance of only three miles, is a caſtle called *Banga*, in which there is a magnificent temple. No one of the miſſionaries ever entered into this caſtle; becauſe the people who have the care of it, have ſuch a ſcrupulous veneration for the temple, that no perſon is permitted to enter it with his ſhoes on; and the miſſionaries, unwilling to ſhew ſuch reſpect to their falſe deities, never entered it. The author of this memoir, however, who acted as phyſician to the commandant, was of courſe admitted within the caſtle, and got a ſight of the celebrated temple, which he declares, that for magnificence he believes ſuperior to every thing in Europe.

Beſides the magnificence of the temples, which their cities and towns contain, there are many other rarities. At Cat'hmandu, on one ſide of the royal garden, there is a large fountain, in which is one of their idols called *Narayan*. This idol is of blue ſtone, crowned and ſleeping on a mattraſs alſo of the ſame kind of ſtone, and the idol and the mattraſs appear as floating upon the water. This ſtone machine is very large, being about 18 or 20 feet long, and broad in proportion, but well worked, and in good repair.

In a wall of the royal palace of Cat'hmandu, which is built upon the court before the palace, there is a great ſtone of a ſingle piece, which is about fifteen feet long, and four or five feet thick; on the top of this great ſtone there are four ſquare holes at equal diſtances from each other; in the inſide of the wall they pour water into the holes; and in the court ſide, each hole having a cloſed canal, every perſon may draw water to drink. At the foot of the ſtone is a large ladder, by which people aſcend to drink; but the curioſity of the ſtone conſiſts in its being quite covered with characters of different languages cut upon it. Some lines contain the characters of the language of the country, others the characters of Tibet, others Perſian, others Greek, beſides ſeveral others of different nations; and in the middle there is a line of Roman characters, which appears in this form, AVTOMNEW INTER LHIVERT; but none of the inhabitants have any knowledge how they came there, nor do they know whether or not any European had ever been in Nepal before the miſſionaries, who arrived there only the beginning of the preſent century. They are manifeſtly two French names of ſeaſons, with an Engliſh word between them.

There is alſo to the northward of the city of Cat'hmandu a hill called *Simbi*, upon which are ſome tombs of the Lamas of Tibet, and other people of high rank of the ſame nation. The monuments are conſtructed after various forms: two or three of them are pyramidal, very high, and well ornamented; ſo that they have a very good appearance, and may be ſeen at a conſiderable diſtance. Round theſe monuments are remarkable ſtones covered with characters, which probably are the inſcriptions of ſome of the inhabitants of Tibet whoſe bones were interred there. The natives of Nepal not only look upon the hill as ſacred, but imagine it is protected by their idols; and from this erroneous ſuppoſition never think of ſtationing troops there for the

Newton.

defence of it, although it be a poſt of great importance, and only at a ſhort mile's diſtance from the city. During the hoſtilities, however, which prevailed when our author was in the country, this ſacred hill was fortified by one of the armies, who, in digging their ditches among the tombs, found conſiderable pieces of gold, with a quantity of which metal the corpſes of the grandees of Tibet are always interred.

The kingdom of Nepal our author believes to be very ancient, becauſe it has always preſerved its peculiar language and independence. It was completely ruined, however, about thirty or forty years ago by the diſſenſions of its nobles, who, on the death of their ſovereign, and, as it would ſeem, the extinction of the royal line, could not agree in their choice of a proper ſucceſſor. The conſequence was, that different ſovereigns were ſet up by the nobles of different diſtricts; and theſe waged war with each other, with a degree of treachery and ſavage atrocity that has hardly a parallel in the annals of the world. Even the Brahmens, whom we are accuſtomed to conſider as a mild and innocent people, were, in the civil wars of Nepal, guilty of the meaneſt and baſeſt villanies: they brought about treaties between the rival ſovereigns, and then encouraged him whom they favoured, to maſſacre the adherents of the other in cold blood.

NEWTON (John), an eminent Engliſh mathematician, was born at Oundle in Northamptonſhire, 1622. After a proper foundation at ſchool, he was ſent to Oxford, where he was entered a commoner of St Edmund's Hall in 1637. He took the degree of bachelor of arts in 1641; and the year following was created maſter, among ſeveral gentlemen that belonged to the king and court, then reſiding in the univerſity. At which time, his genius being inclined to aſtronomy and the mathematics, he applied himſelf diligently to thoſe ſciences, and made a great proficiency in them, which he found of ſervice during the times of the uſurpation. After the reſtoration of Charles II. he reaped the fruits of his loyalty; being created doctor of divinity at Oxford Sept. 1661, he was made one of the king's chaplains, and rector of Roſs in Herefordſhire, in the place of Mr John Toombes, ejected for nonconformity. He held this living till his death, which happened at Roſs on Chriſtmas-day 1678. Mr Wood gives him the character of a capricious and humourſome perſon: however that may be, his writings are ſufficient monuments of his genius and ſkill in the mathematics. Theſe are, 1. *Aſtronomia Britannica*, &c. in three parts, 1656, in 4to. 2. Help to Calculation; with Tables of Declination, Aſcenſion, &c. 1657, 4to. 3. *Trigonometria Britannica*, in two books, 1658, folio; one compoſed by our author, and the other tranſlated from the Latin of Henry Gellibrand. 4. *Chiliades centum Logarithmorum*, printed with, 5. Geometrical Trigonometry, 1659. 6. Mathematical Elements, three parts, 1660, 4to. 7. A perpetual Diary or Almanac, 1662. 8. Deſcription of the Uſe of the Carpenter's Rule, 1667. 9. Ephemerides, ſhewing the Intereſt and rate of Money at 6 *per cent.* &c. 1667. 10. *Chiliades centum Logarithmorum, et Tabula Partium proportionalium*, 1667. 11. The Rule of Intereſt, or the Caſe of Decimal Fractions, &c. Part II. 1668, 8vo. 12. School-Paſtime for young Children, &c. 1669, 8vo. 13. Art of practical Gauging, &c. 1669. 14. Introduction to the Art of Rhetoric, 1671. 15. The Art of Natural Arithmetic, in whole Numbers, and Fractions Vulgar and Decimal, 1671, 8vo. 16. The Engliſh Academy, 1673, 8vo. 17. Coſmography. 18. Introduction to Aſtronomy. 19. Introduction to Geography, 1678, 8vo *.

Nicole.

NICOLE (Francis), a very celebrated French mathematician, was born at Paris December 23. 1683. His early attachment to the mathematics induced M. Montmort, to take the charge of his education; and he opened out to him the way to the higher geometry. He firſt became publicly remarkable by detecting the fallacy of a pretended quadrature of the circle. This quadrature a M. Mathulon ſo aſſuredly thought he had diſcovered, that he depoſited, in the hands of a public notary at Lyons, the ſum of 3000 livres, to be paid to any perſon who, in the judgment of the Academy of Sciences, ſhould demonſtrate the falſity of his ſolution. M. Nicole, piqued at this challenge, undertook the taſk, and expoſing the paralogiſm, the Academy's judgment was, that Nicole had plainly proved that the rectilineal figure which Mathulon had given as equal to the circle, was not only unequal to it, but that it was even greater than the polygon of 32 ſides circumſcribed about the circle. The prize of 3000 livres Nicole preſented to the public hoſpital of Lyons.

The Academy named Nicole, Eleve-Mechanician, March 12. 1707; Adjunct in 1716, Aſſociate in 1718, and Penſioner in 1724; which he continued till his death, which happened the 18th of January 1758, at 75 years of age.

His works were all inſerted in the different volumes of the Memoirs of the Academy of Sciences; and are as follow: 1. A General Method for determining the Nature of Curves formed by the Rolling of other Curves upon any Given Curve; in the volume for the year 1707. 2. A General Method for Rectifying all Roulets upon Right and Circular Baſes, 1708. 3. General Method of determining the Nature of thoſe Curves which cut an Infinity of other Curves given in Poſition, cutting them always in a Conſtant Angle, 1715. 4. Solution of a Problem propoſed by M. de Lagny, 1716. 5. Treatiſe of the Calculus of Finite Differences, 1717. 6. Second Part of the Calculus of Finite Differences, 1723. 7. Second Section of ditto, 1723. 8. Addition to the two foregoing papers, 1724. 9. New Propoſition in Elementary Geometry, 1725. 10. New Solution of a Problem propoſed to the Engliſh Mathematicians, by the late M. Leibnitz, 1725. 11. Method of Summing an Infinity of New Series, which are not ſummable by any other known method, 1727. 12. Treatiſe of the Lines of the Third Order, or the Curves of the Second Kind, 1729. 13. Examination and Reſolution of ſome Queſtions relating to Play, 1730. 14. Method of determining the Chances at Play. 15. Obſervations upon the Conic Sections, 1731. 16. Manner of generating in a Solid Body all the Lines of the Third Order, 1731. 17. Manner of determining the Nature of Roulets formed upon the Convex Surface of a Sphere; and of determining which are Geometric and which are Rectifiable, 1732. 18. Solution of a Problem in Geometry, 1732. 19. The Uſe of Series in reſolving many Problems in the Inverſe Method of Tangents, 1737. 20. Obſervations on the Irreducible Caſe in Cubic Equations, 1738. 21. Obſervations upon Cubic Equations, 1738. 22. On the Triſection of an Angle, 1740. 23. On the Irreducible Caſe in Cubic Equations, 1741. 24. Addition to ditto, 1743. 25. His Laſt Paper upon the ſame, 1744. 26. Determination, by Incommenſurables and Decimals, the Values of the Sides and Areas of the Series in a Double Progreſſion of Regular Polygons, inſcribed in and circumſcribed about a Circle, 1747 *.

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* Biog. Dict. new edit.

*Hutton's Dictionary.

NIEUWLAND (Peter), profeſſor of mathematics and natural philoſophy in the univerſity of Leyden, was born at Diemermeer, a village near Amſterdam, on the 5th of November, 1764. His father, by trade a carpenter, having a great fondneſs for books, and being tolerably well verſed in the mathematics, inſtructed his ſon himſelf till he attained to his eleventh year. Young Nieuwland appears to have diſplayed ſtrong marks of genius at a very early period. When about the age of three, his mother put into his hand ſome prints, which had fifty verſes at the bottom of them by way of explanation. Theſe verſes ſhe read aloud, without any intention that her ſon ſhould learn them; and ſhe was much ſurpriſed ſome time after to hear him repeat the whole from memory, with the utmoſt correctneſs, on being only ſhewn the prints.

Before he was ſeven years of age he had read more than fifty different books, and in ſuch a manner that he could frequently repeat paſſages from them both in proſe and in verſe. When about the age of eight, Mr Aeneæ at Amſterdam, one of the greateſt calculators of the age, aſked him if he could tell the ſolid contents of a wooden ſtatue of Mercury which ſtood upon a piece of clock-work. "Yes (replied young Nieuwland), provided you give me a bit of the ſame wood of which the ſtatue was made; for I will cut a cubic inch out of it, and then compare it with the ſtatue." Poems which (ſays his eulogiſt) diſplay the utmoſt livelineſs of imagination, and which he compoſed in his tenth year, while walking or amuſing himſelf near his father's houſe, were received with admiration, and inſerted in different poetical collections.

Such an uncommon genius muſt ſoon burſt through thoſe obſtacles which confine it. Bernardus and Jeronimo de Boſch, two of the firſt and wealthieſt men at Amſterdam, became young Nieuwland's benefactors, and contributed very much to call forth his latent talents. He was taken into the houſe of the former in his eleventh year, and he received daily inſtruction from the latter for the ſpace of four years. While in this ſituation he made conſiderable progreſs in the Latin and Greek languages, and he ſtudied philoſophy and the mathematics under Wyttenbach. In the year 1783 he tranſlated the two diſſertations of his celebrated inſtructors, Wyttenbach and de Boſch, on the opinions which the ancients entertained of the ſtate of the ſoul after death, which had gained the prize of the Teylerian theological ſociety.

From the month of September 1784 to 1785, Nieuwland reſided at Leyden as a ſtudent in the univerſity, and afterwards applied with great diligence, at Amſterdam, to natural philoſophy and every branch of the mathematics, under the direction of Profeſſor van Swinden. He had ſcarcely begun to turn his attention to chemiſtry, when he made himſelf maſter of the theory of the much-lamented Lavoiſier, and could apply it to every phenomenon. He could read a work through with uncommon quickneſs, and yet retain in his mind the principal part of its contents.

Nieuwland's attention was directed to three principal purſuits, which are ſeldom united; poetry, the pure mathematics, and natural philoſophy. In the latter part of his life he added to theſe alſo aſtronomy. Among the poems which he publiſhed, his Orion alone has rendered his name immortal in Holland. Of the ſmall eſſays which he publiſhed in his youth, the two following are particularly deſerving of notice: 1. A Comparative View of the Value of the different Branches of Science; and, 2. The Beſt Means to render general, not Learning, but Soundneſs of Judgment and Good Taſte.

One of his great objects was to bring the pure mathematics nearer to perfection, to clear up and connect their different parts, and in particular to apply them to natural philoſophy and aſtronomy. Cornelius Douwes diſcovered an eaſy method of determining the latitude of a place at ſea, not by the meridian altitude of the ſun, but by two obſervations made at any other period of the day. This method, however, being ſtill imperfect, Nieuwland turned his thoughts towards the improvement of it, and in the beginning of the year 1789 wrote a paper on the ſubject, which he tranſmitted to M. de Lalande at Paris, from whom it met with great approbation. In the year 1792, when Nieuwland reſided two months at Gotha with Major von Zach, theſe two learned men often converſed on this method of finding the latitude, and calculated the reſult of obſervations which they had made with a ſextant and an artificial horizon. The above paper, enlarged by theſe obſervations, was inſerted by Major von Zach with Nieuwland's name in the firſt Supplement to Bode's Aſtronomical Almanack, Berlin, 1793.

This, however, was not the only ſervice which Nieuwland endeavoured to render to aſtronomy. It had been obſerved by Newton, Euler, De la Place, and others, that the axes of the planets do not ſtand perpendicular, but inclined, to the plane of their orbits; and Du Sejour, in his analytical treatiſe on the apparent motion of the heavenly bodies, conſiders it as highly probable that this phenomenon depends on ſome *phyſical* cauſe; which, however, he does not venture to aſſign. Nieuwland proceeded farther, and laid down principles, from which he drew this concluſion, that the above phenomenon is intimately connected with the whole ſyſtem of attraction. On theſe principles he made calculations, the reſult of which was exactly equal to the angle of the inclination of the earth's axis to the plane of its orbit. Nieuwland communicated his diſcovery with much modeſty to the celebrated Profeſſor Damen at Leyden, who propoſed ſome objections to it which diſcouraged Nieuwland, and induced him to reviſe his calculations with more accuracy. Major von Zach tranſmitted the paper which contained them to M. De la Place at Paris, and cauſed it to be printed alſo, for the opinion of the learned, in the Supplement to Profeſſor Bode's Aſtronomical Almanack for the year 1793.

The writer of this article is not acquainted either with the principles which this young aſtronomer aſſumed, or with the calculations which he made from them; but if he holds gravitation to be eſſential to matter, and the inclination of the axes of the planets to be the neceſſary reſult of the law of gravitation, he is undoubtedly in an error. The axes of the planets are not all equally inclined, nor does the inclination vary in exact proportion to the ſquares of the diſtances.

Nieuwland's talents and diligence ſoon recommended him to the notice of his country. In his twenty-ſecond year, he was appointed a member of the commiſſion choſen by the College of Admiralty at Amſterdam for determining the longitude and improving marine charts. On this labour he was employed eight years, and undertook alſo to prepare a nautical almanack, and to calculate the neceſſary tables. The mathematical part was in general entruſted to Nieuwland; but he aſſiſted alſo his two colleagues van Swinden and van Keulen, in the departments aſſigned to them, with ſuch aſſiduity, that moſt of the work publiſhed on the longitude, together with the three additional parts, were the fruits of his labour. In the ſecond edition of the explanation of the nautical almanack, he had alſo the principal ſhare; and he was the author, in particular, of the explanation of the equation of time, the method of determining the going of a time-piece, and of calculating the declination of the moon.

Soon after Nieuwland engaged in this employment, it appeared as if his deſtination was about to be changed. In the year 1787, he was choſen by the States of Utrecht to ſucceed Profeſſor Hennert; but on account of certain circumſtances this appointment did not take place. He was, however, invited to Amſterdam by the magiſtrates of that city, to give lectures on mathematics, aſtronomy, and navigation. While in this ſituation, he wrote his uſeful and excellent treatiſe on navigation, the firſt part of which was publiſhed at Amſterdam in 1793, by George Hulſt van Keulen; and it is much to be wiſhed that M. van Swinden would complete this work from the papers bequeathed to him by his deceaſed friend the author.

In aſtronomical purſuits, Nieuwland applied not only to the theoretical, but alſo to the practical part; and in this ſtudy he was encouraged and aſſiſted by Major von Zach, with whom he reſided ſome time in the courſe of the year 1792, and who inſtructed him in the proper uſe of the ſextant. This affectionate friend publiſhed alſo all his obſervations and calculations in the before-mentioned Supplement to Bode's Aſtronomical Almanack.

In the year 1789, Nieuwland was choſen member of a learned ſociety whoſe object was chemical experiments; and ſo apt was his genius for acquiring knowledge, that in a little time he made himſelf completely maſter of the theory of chemiſtry. A proof of this is the treatiſe which he read on the 24th of May 1791, in the ſociety, diſtinguiſhed by the motto of *Felix Meritis*, and which has been printed in the firſt part of the New General Magazine (*Niew Algemeen Magazyn*). At the ſame time he was able to examine the important diſcoveries made by the ſociety, to aſſiſt in preparing an account of them for the preſs, and to publiſh them with ſufficient accuracy in the French language. Three parts of this work appeared under the title of *Recherches Phyſico-chymiques*. The firſt part appeared in 1792, and was afterwards reprinted in the *Journal de Phyſique*. The ſecond was publiſhed in 1793, and the fourth in 1794. Some letters of his on chemiſtry may be found alſo in a periodical work called *The Meſſenger* (*Letterbode*).

This ingenious and diligent man was of great ſervice alſo in the philoſophical department to the above ſociety, *Felix Meritis*, of which he had been choſen a titular member on the 25th of January 1788, and an honorary member on the 15th of March 1791. The papers for which it was indebted to him are as follows:—1. On the Neweſt Diſcoveries in Aſtronomy, and the Progreſs lately made in that Science, 1788. This is an extract from a Latin oration which he intended to deliver at Utrecht when he expected to ſucceed Profeſſor Hennert.—2. On the Figure of the Earth, 1789.—3. On the Courſe of Comets, and the Uncertainty of the Return of the Comet now Expected, 1790.—4. On the Nature of the Mathematics. The principal object of this paper was to illuſtrate the idea, that the mathematics may be conſidered as a beautiful and perfect language.—5. On the Periodical Decreaſe or Increaſe in the Light of Certain Fixed Stars, and Particularly of the Star Algol, 1790.—6. On the Solution of Spherical Trigonometry by Means of a New Inſtrument Invented by Le Guin, 1791. M. le Guin having tranſmitted to the College of Admiralty at Amſterdam an inſtrument which might be uſed with great advantage in trigonometrical operations, and by which, in calculating the longitude, one could deduce the real from the apparent diſtance, the admiralty charged Nieuwland to examine this inſtrument; and he found that it might be of excellent ſervice for the above purpoſe.—7. On the Relative Value or Importance of the Sciences, 1791.—8. On the Syſtem of Lavoiſier, 1792.—9. On the Selenotopographia of Schröder, 1793.—10. On what is Commonly Called Cultivation, Inſtruction, or Enlightening, 1793.

Nieuwland had applied cloſely to the mathematics, aſtronomy, and navigation, for ſix years; during which time he made conſiderable improvements in nautical charts, and filled up his vacant hours with the ſtudy of philoſophy and chemiſtry. In the month of July 1793 he was invited to the univerſity of Leyden, to be profeſſor of philoſophy, aſtronomy, and the higher mathematics, in the room of the celebrated Damen; and the admiralty of Amſterdam requeſted him to continue his nautical reſearches, which he did with great aſſiduity till the period of his death. The only variation which he now made in his ſtudies related to natural philoſophy, for with the mathematics he was already ſufficiently acquainted. He applied therefore to the experimental part, and ſpared no pains nor labour to become perfect in it; which would certainly have been the caſe, had he not been ſnatched from ſcience and his friends at the early age of thirty. He died of an inflammation in his throat, accompanied with a fever, on the 13th of November 1794.

In his external appearance, Nieuwland was not what might be called handſome, nor had he ever been at pains to acquire that eaſe of deportment which diſtinguiſhes thoſe who have frequented polite company. His behaviour and converſation were however agreeable, becauſe he could diſcourſe with facility on ſo many ſubjects, and never wiſhed to appear but under his real character. On the firſt view one might have diſcerned that he was a man of great modeſty and the ſtricteſt morality. His father was a Lutheran, and his mother a baptiſt; but he himſelf was a member of what is called the reformed church, *i. e.* a Calviniſt, and always ſhewed the utmoſt reſpect for the Supreme Being both by his words and his actions.

NIGER, a large river in Africa, of which many erroneous accounts have been publiſhed, and among them that which we have given in the *Encyclopædia Britannica*. By Herodotus, Pliny, Ptolemy, and other ancient authors, it is uniformly ſaid to flow from *weſt* to *eaſt*, dividing Africa as the Danube divides Europe; and from the report of the Africans, the firſt of theſe authors calls it a large river abounding with crocodiles. In the twelfth century, however, Edriſi deſcribes the Niger, which he calls the Nile of the negroes, as running from *eaſt* to *weſt*, and falling into the Atlantic Ocean; and his account was univerſally adopted by ſubſequent writers, till its falſehood was diſcovered by the African Aſſociation. From a number of concurring reports, Major Houghton was led to believe that the courſe of the Niger is from *weſt* to *eaſt*, according to the moſt ancient account; and the truth of theſe reports has been eſtabliſhed beyond all controverſy by Mr Park, who ſaw the Niger himſelf, and actually accompanied it for many miles in its majeſtic courſe as laid down by Herodotus.

This river riſes in or near the country of Manding (which ſee in this *Supplement*), between the parallels of 10 and 11 degrees of north latitude, and between the 5th and 9th degree of weſt longitude, which comprehends a ſpace the moſt elevated of all this portion of Africa. This is evident from the oppoſite courſes of the three great rivers which riſe in it. Theſe are the Gambia, which runs to the weſt-north-weſt; the Senegal, which runs to the north-weſt; and the Joliba (A), or Niger, running to the eaſt-north-eaſt. The head of the principal branch of the Senegal river is about 80 geographical miles to the weſt of that of the Niger; and the head of the Gambia is again about 100 miles weſt of the Senegal.

Mr Park traced the Niger to Silla, a conſiderable town about 420 miles from its ſource; and it was there larger than the Thames at Weſtminſter. But 420 miles are but a very ſmall part of the courſe of the Niger, which doubtleſs receives many tributary ſtreams before it reach Kaſſina, 700 miles farther eaſtward, where there is every reaſon to believe that it was viewed by the ancient Romans. Our traveller collected at Silla what information he could from the Mooriſh and Negro traders concerning the further courſe of this majeſtic ſtream, as well as of the kingdoms through which it runs; and the following notices he believes to be authentic:

Two ſhort days journey to the eaſtward of Silla, is the town of Jenne, which is ſituated on a ſmall iſland in the river; and is ſaid to contain a greater number of inhabitants than Sego itſelf, or any other town in Bambarra. (See Sego, *Suppl.*) At the diſtance of two days more, the river ſpreads into a conſiderable lake, called *Dibbie* (or the dark lake); concerning the extent of which, all the information which our author could obtain was, that in croſſing it, from weſt to eaſt, the canoes loſe ſight of land one whole day. From this lake, the water iſſues in many different ſtreams, which terminate in two large branches, one whereof flows towards the north-eaſt, and the other to the eaſt; but theſe branches join at Kabra, which is one day's journey to the ſouthward of Tumbuctoo, and is the port or ſhipping-place of that city. The tract of land which the two ſtreams encircle, is called Jinbala, and is inhabited by negroes; and the whole diſtance by land, from Jenne to Tumbuctoo, is twelve days journey.

From Kabra, at the diſtance of eleven days journey, down the ſtream, the river paſſes to the ſouthward of Houſſa, which is two days journey diſtant from the river. Of the further progreſs of this great river, and its final exit, all the natives with whom Mr Park converſed ſeemed to be entirely ignorant. Their commercial purſuits ſeldom induce them to travel further than the cities of Tumbuctoo and Houſſa; and as the ſole object of thoſe journeys is the acquirement of wealth, they pay but little attention to the courſe of rivers, or the geography of countries. It is, however, highly probable that the Niger affords a ſafe and eaſy communication between very remote nations. All our author's informants agreed, that many of the negro merchants who arrive at Tumbuctoo and Houſſa, from the eaſtward, ſpeak a different language from that of Bambarra, or any other kingdom with which they are acquainted. But even theſe merchants, it would ſeem, are ignorant of the termination of the river; for ſuch of them as can ſpeak Arabic, deſcribe the amazing length of its courſe in very general terms, ſaying only, that they believe *it runs to the world's end*.

Major Rennel, by comparing a great many accounts of the progreſs of this river beyond Houſſa, with the idea which prevails in that city of its termination, has ſhewn it to be in a very high degree probable, that the waters of the Niger have no direct communication with the ſea, but that they are ſpread out into a great lake in Wangara and Ghana, and evaporated by the heat of the ſun. See Wangara in this *Supplement*.

NILE, the name of a celebrated river, which, as it has been deſcribed in the *Encyclopædia*, ſhould not have been introduced into this place, did we not think ourſelves bound candidly to confeſs that, in our opinion, its ſources, at leaſt thoſe ſources which were the objects of ancient curioſity, have never yet been ſeen by any European. This ſeems to be proved, beyond the poſſibility of controverſy, by Major Rennel in the Appendix to Mr Park's Travels, and by Mr Browne in his account of the *Bahr-el-abiad*, and *Dar-Fur* or *Soudan*. See Soudan in this *Supplement*.

Mr Bruce himſelf acknowledges that the Nile, which waters Egypt, is the confluence of two ſtreams, and that the weſtern ſtream, which he, with others, calls *Bahr-el-abiad*, or the *white river*, is the largeſt of the two. Were a man therefore to travel from Cairo up the banks of the Nile in queſt of its ſource, he would, doubtleſs, when he ſhould arrive at the diviſion of the river into two channels, continue his journey up the greater of theſe; for what could induce him to turn aſide with the leſs? Not the *name*; for neither the leſs nor the greater has by itſelf the name which, in Egypt, is given to both when united. The former, which undoubtedly has its ſource in Abyſſinia, is there called the Abay or Abavi; and, in other countries through which

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(A) This is the negro name of the river, and ſignifies the *great water*.

which it runs, the Bahr-el-Afrek; the latter is, from its ſource to its junction with the Abay, called the Bahr-el abiad. Pliny believed that the Nile came from the weſt; and Ptolemy ſays expreſsly that its remote ſource is in the *mountains of the moon.* But this Nile muſt be the White River, which certainly riſes to the weſtward of Abyſſinia, and, according to Abulfeda, in the mountains of Komri or Kummeri; which, in Arabic, ſignifies *lunar,* being the adjective of Kummer, the moon.

In perfect conformity with this ancient account of the ſource of the Nile, Mr Ledyard was told at Cairo by certain perſons from Dar-Fur, that this celebrated river has its coy fountains in their country, at the diſtance of 55 days journey to the weſtward of Senaar, which brings them to the Komri mountains of Abulfeda, who, as well as Ptolemy and Edriſi, places the head of the Nile in a quarter far removed from Abyſſinia. Ptolemy has indeed mentioned both branches; and while he deſcribes the eaſtern in ſuch a way as that it cannot be taken for any other than the Abyſſinian branch, or the Nile of Bruce and the Portugueſe Jeſuits, ſpeaks of a larger branch flowing from a more diſtant ſource, ſituated to the ſouth-weſt. But this can be no other than Bruce's white river, the *Bahr-el-abiad* of Ledyard and Browne. It is true, there is an apparent difference in the account given by theſe two laſt mentioned travellers of the country in which the Bahr-el-abiad riſes; but it is a difference only apparent. Ledyard was told at Cairo that it riſes in Dar-Fur; Mr Browne, who reſided long in Dar-Fur, was there told, that the ſources of the river are near to a place called *Donga,* the reſidence of the chief or king of an idolatrous nation to the ſouthward of Dar-Fur. It is to be obſerved, however, that the ſlave-merchants who trade between Donga and Cairo are always attached to the Soudan or Dar-Fur caravan; and that therefore the perſons who told Ledyard that the Nile riſes in their country were probably from Donga; though he took them for Furians from the name of their caravan. Mr Browne informs us, that the country about Donga is very mountainous, and that in the ſpot where the river riſes there are ſaid to be forty diſtinct hills, which are called *Kumri.* From them iſſues a great number of ſprings, that, uniting into one great channel, form the Bahr-el-abiad, which ſuffers the ſame periodical increaſe and diminution as the Nile in Egypt. The people of Donga are quite naked, black, and, as we have already obſerved, idolaters. Major Rennel places the mountains of the moon between 5° 40′ and 8° 10′ N. Lat. and between 24° 30′ and 30° 25′ E. Long. Their latitude and longitude, as laid down by Mr Browne, are ſomewhat, tho' very little, different; whilſt Geeſh, the ſource of Bruce's Nile, lies between the 10th and 11th degree of N. Lat. and in about the 37th degree of E. Long.

NIMIQUAS, a nation, or, more properly, two tribes in South Africa, called by Vaillant the *Leſs* and *Greater* Nimiquas.

The country of the Leſs Nimiquas extends in longitude from the mountains of Camis to the ſea on the weſt, *i. e.* from 15° 25′ to 18° 25′ eaſt from London, and in latitude from 28° 12′ to 29° 36′ ſouth. From the information which our author could collect, he thinks that the number of inhabitants throughout the whole of this tract does not exceed 6000 ſouls. Even this number is annually diminiſhed by the frequent attacks of Boſhmen, and the aridity of the ſoil. Of the BOSHMEN we have already given ſuch an account as can leave no doubt of the deſtructive nature of their incurſions; and the ſoil muſt be arid indeed, if it be true, as Vaillant aſſures us, that in the country of the Leſs Nimiquas rain never falls except when it thunders, and that thunder is ſo rare as frequently not to be heard for the ſpace of a whole year.

For this want of rain our author accounts in a ſatisfactory manner: "The country (he ſays) having neither foreſts nor lofty mountains to arreſt the clouds, thoſe which come from the north paſs freely over it, and proceed on to Camis, where they burſt and fall, either in rain in the valleys, or in ſnow on the ſummits of theſe mountains, which are the loftieſt throughout the ſouth of Africa." The country is of courſe not fruitful, and its ſterility obliges the inhabitants frequently to change their reſidence, ſo that they are the moſt wandering of all the Hottentot tribes. In this barren region the Dutch coloniſts ſuppoſe that gold mines may be found; but our author diſcovered among the hordes no traces of this metal, though he found many indications of rich copper mines.

The Leſs Nimiquas, though of a tolerable ſtature, are not ſo tall as their neighbours to the eaſtward; and indeed Vaillant affirms, that the people to the eaſt in the ſouthern part of Africa are much ſuperior to thoſe of the weſt both in moral and phyſical qualities, while the animals are far inferior. The Leſs Nimiquas are great believers in witchcraft; and our author gives a ridiculous account of an interview that he had with an old witch named *Kakoes,* who had a complete aſcendency, not only over the whole horde, but alſo over the ſavage Boſhmen. Theſe robbers, he ſays, never attempted to plunder the territory where ſhe took up her reſidence; and ſhe has been known, when their thefts came to her knowledge, to proceed alone, and unguarded, to their retreats in the midſt of the woods, to threaten them with her vengeance, and thus compel them to a reſtitution of the ſtolen property. All her influence, however, over her own tribe, could procure for our author and his attendants only ſix ſheep.

The women of the horde received his Hottentots with great kindneſs; and permitted them to diſcover very ſingular charms, of which it is needleſs here to inſert a deſcription. Among this people he ſaw abundance of bracelets, necklaces, and ear-rings of copper; and ſome of theſe ornaments were ſo well made and finely poliſhed, that they muſt have been manufactured in Europe, and the fruits of an intercourſe with the whites. But he ſaw ſeveral others, which, from their groteſque ſhape and rude workmanſhip, evidently ſhewed that they were fabricated by the ſavages themſelves.

"Theſe ornaments (ſays he) are worn by the Nimiquas in the ſame manner as by the other ſavages; yet I obſerved among them ſome whimſical peculiarities. I have ſeen perſons with ſix ear-rings of the ſame ſhape in one ear, and none in the other: I have ſeen ſome with bracelets from the wriſt to the elbow on one arm, while the other arm was bare: I have ſeen others with one ſide of the face painted in compartments of various colours, while on the other ſide both the colours and figures were different. In general, I obſerved great propenſity to ornaments among the Leſs Nimiquas;

for their kroſſes and all their garments were plentifully covered with glaſs and copper beads, ſtrung on threads, and faſtened on every part of their dreſs. They even wore them in their hair, which was plaſtered with greaſe in the moſt diſguſting manner. Many had their heads covered with a reddiſh incruſtation, compoſed of greaſe and a powder reſembling brick-duſt, with which their hair was ſo paſted together, that you would have ſworn it to be a cap of red mortar. Thoſe who had it in their power to diſplay this luxury of dreſs, were as proud as are our *petits-maitres*, when they can ſhake a head loaded with powder, perfume, and pomatum. The *nuyp-kros*, or ſhort apron, of the women, was adorned with rows of glaſs beads hanging down to their feet; in other reſpects they were dreſſed like the other Hottentots."

The country of the *Greater Nimiquas* is placed by the author in nearly the ſame longitude with that of the Leſs, and between 25° and 28° ſouth latitude. It is barren like the other; but the people are much taller, being generally about five feet ten inches high. The men are dull and ſtupid, but the women are lively and extremely amorous; and both men and women are comparatively handſome and of a ſlender make. Extravagantly addicted to ſmoking tobacco, the young girls bartered their favours for a ſingle pipe; and as Vaillant was chief of the caravan, a white, and poſſeſſor of tobacco of much better quality, many advances were made to him. "I have do doubt (ſays he) but I might have formed, for a few pipefuls only, an alliance with every family in the horde. I was even preſſed ſo cloſely, as to be obliged to employ ſome reſiſtance: but, at the ſame time, I muſt confeſs, that my refuſals were given in ſuch a way as not to offend; and they who, in conſequence of their advances, had been expoſed to them, having ſoon found other arrangements to make, did not ſhew me the leſs friendſhip. I muſt here add, that the girls alone appeared to me thus free; while the married women on the contrary were modeſt and reſerved. This is a characteriſtic difference, which diſtinguiſhes the Greater Nimiquas from the Hottentot people in general; as likewiſe does the low cringing air they aſſume when they have any thing to aſk."

It has been ſaid by Kolben, that the Nimiqua women, when they bear twins, deſtroy one of the infants; but Vaillant aſſures us that this is a falſehood, as is likewiſe another tale which is current in the colony. It has been ſaid that the fathers, to ſhew what affection they bear their children, feed their eldeſt in a particular manner, as being of right the firſt object of paternal care. For this purpoſe they put him in a coop as it were; that is, they ſhut him up in a trench made under their hut, where, being deprived of motion, he loſes little by perſpiration, while they feed and cram him in a manner with milk and greaſe. By degrees the child fattens, and gets as round as a barrel; and when he is come to ſuch a ſtate as not to be able to walk, but to bend under his own weight, the parents exhibit him to the admiration of the horde; who from that period conceive more or leſs eſteem and conſideration for the family, according as the monſter has acquired more or leſs rotundity.

Such was the account given to our author by a man who affirmed that he had been an eye-witneſs of this mode of cramming the heir-apparent; but whenever any queſtions were aſked on the ſubject of the Nimiquas themſelves, the perſons addreſſed were ready to laugh in our author's face. "Still (ſays he), as it appeared ſtrange to me, that a man ſhould talk of what he had ſeen, when he had in reality ſeen nothing; as it was poſſible that the fable might have ſome foundation, without being true in all particulars—I was willing to convince myſelf what could have given riſe to it; and every time I viſited a horde, I took care, under different pretences, to examine, one after another, all the huts of the kraal, and to aſk which was the eldeſt child of the family: but I nowhere ſaw any thing that indicated either this pretended coop, or this pretended cramming."

The Nimiquas are great cowards; yet, like the ſurrounding nations, they have their aſſagays and poiſoned arrows; and, like them, can handle theſe arms with dexterity. They poſſeſs alſo thoſe war oxen, ſo formidable in battle, and ſo favourable to the cowardice or inactivity of the combatants. They have even a peculiar implement of war, which their neighbours have not. This is a large buckler, of the height of the perſon who bears it, behind which the Nimiqua can completely conceal himſelf. But, beſide that his natural apathy prevents him from giving or taking offence, he is in reality puſillanimous and cowardly from the coldneſs of his diſpoſition. To utter only the name of *Houzouana* before him is ſufficient to make him tremble. See Houzouanas in this *Suppl.*

Notwithſtanding his frigidity, the Nimiqua is not inſenſible to pleaſure. He even ſeeks with avidity thoſe which, requiring but little exertion, are capable of agitating him and procuring agreeable ſenſations. Their muſical inſtruments are the ſame as thoſe of the other Hottentots; but their dancing is very different, and reſembles the temper of the nation. If the countenance have received from nature features that can expreſs our paſſions, the body alſo has its attitudes and movements that paint our temper and feelings. The dance of the Nimiqua is frigid like himſelf, and ſo devoid of grace and hilarity, that, were it not for the extreme gaiety of the women, it might be called the dance of the dead.

Theſe tortoiſes, to whom dancing is a fatigue, ſhew little eagerneſs for any thing but wagers, games of calculation and chance, and all the ſedentary amuſements which require patience and reflection, of which they are more capable than they are of motion. When our author, with great propriety, prohibited gaming in his camp, the Nimiquas, who had ſtaid long with him, took their departure.

NITTA, a ſpecies of the Mimosa, which flouriſhes on the banks of the Senegal in Africa. It is valuable to the inhabitants for its fruit, the pods of which are long and narrow, containing a few black ſeeds enveloped in a fine mealy powder, of a bright yellow colour, which reſembles the flour of ſulphur, and has a ſweet mucilaginous taſte. When eaten by itſelf it is clammy; but when mixed with milk or water, it conſtitutes a very pleaſant and nouriſhing food, ſupplying the place of corn to the negroes.—*Park's Travels.*

NIZOLIUS (Marius), a grammarian of Italy, who by his wit and erudition contributed much to the promotion of letters in the 16th century. He publiſhed, in 1553, *Lib.* 4. *De veris Principiis et vera Ratione philoſo-*

philoſophandi, contra Pſeudo-philoſophos. In this work he attacks, with much vivacity, the ſchoolmen, not only for the barbariſm of their terms, but for many ridiculous opinions which they held. Leibnitz was ſo ſtruck with its ſolidity and elegance, that, to expoſe the obſtinacy of thoſe who were zealouſly attached to Ariſtotle, he gave a new edition of it, with critical notes of his own, 1670, in 4to. Nizolius publiſhed alſo, *Theſaurus Ciceronianus, ſive Apparatus Linguæ Latinæ e Scriptis Tullii Ciceronis collectus*, in folio. This is a good Latin dictionary, compoſed of the words and expreſſions of Cicero; to which, it ſeems, Nizolius ſhewed as much bigotry as the ſchoolmen to their notions; and fell under the character of thoſe pedants whom Eraſmus has ridiculed in his *Ciceronianus*. We do not find the year either of his birth or death.

Biog. Dictionary.

NOCTURNAL ARCH, is the arch of a circle deſcribed by the ſun, or a ſtar, in the night.

NONAGESIMAL, or NONAGESIMAL *Degree*, called alſo the *Mid heaven*, is the higheſt point, or 90th degree of the ecliptic, reckoned from its interſection with the horizon at any time; and its altitude is equal to the angle that the ecliptic makes with the horizon at their interſection, or equal to the diſtance of the zenith from the pole of the ecliptic. It is much uſed in the calculation of ſolar eclipſes.

NONAGON, a figure having nine ſides and angles. In a regular nonagon, or that whoſe angles and ſides are all equal, if each ſide be 1, its area will be 6·1818242 = $\frac{9}{4}$ of the tangent of 70°, to the radius 1.

NORMAL, is uſed ſometimes for a perpendicular.

NUEL, or NEWEL, the upright poſt about which ſtairs turn, being that part of the ſtaircaſe which ſuſtains one end of the ſteps.

O.

OASIS (plur. OASES), a fertile ſpot in the midſt of a ſandy deſart. In the SAHARA, or Great Deſart of Africa, there are many *Oaſes* of extreme fertility.

OBLATE, flatted or ſhortened; as an oblate ſpheroid, having its axis ſhorter than its middle diameter; being formed by the rotation of an ellipſe about the ſhorter axis.

OBLIQUE ASCENSION, is that point of the equinoctial which riſes with the centre of the ſun, or ſtar, or any other point of the heavens, in an oblique ſphere.

OBLIQUE Circle, in the ſtereographic projection, is any circle that is oblique to the plane of projection.

OBLIQUE Deſcenſion, that point of the equinoctial which ſets with the centre of the ſun, or ſtar, or other point of the heavens, in an oblique ſphere.

OBLIQUE Force, or *Percuſſion*, or *Power*, or *Stroke*, is that made in a direction oblique to a body or plane. It is demonſtrated, that the effect of ſuch oblique force, &c. upon the body, is to an equal perpendicular one, as the ſine of the angle of incidence is to radius.

OBLONG SPHEROID, is that which is formed by an ellipſe revolved about its longer or tranſverſe axis; in contradiſtinction from the *oblate ſpheroid*, or that which is flatted at its poles, being generated by the revolution of the ellipſe about its conjugate or ſhorter axis.

OBSERVATORY, PORTABLE. See ASTRONOMY, n 504, *Encycl.*

OCCIDENT EQUINOCTIAL, that point of the horizon where the ſun ſets, when he croſſes the equinoctial, or enters the ſign Aries or Libra.

OCCIDENT Eſtival, that point of the horizon where the ſun ſets at his entrance into the ſign Cancer, or in our ſummer when the days are longeſt.

OCCIDENT Hybernal, that point of the horizon where the ſun ſets at midwinter, when entering the ſign Capricorn.

OCTANT, the eighth part of a circle.

ODD, in arithmetic, is ſaid of a number that is not even. The ſeries of odd numbers is 1, 3, 5, 7, &c.

ODDLY-ODD. A number is ſaid to be oddly odd, when an odd number meaſures it by an odd number. So 15 is a number oddly odd, becauſe the odd number 3 meaſures it by the odd number 5.

ODOUR, that quality of certain bodies which excites the ſenſation of ſmell. In the *Annales de Chimie*, Vol. XXI. p. 254, we have a detailed account of certain experiments made by M. Benedict Prevoſt of Geneva, with a view to render the *emanations of odorant bodies perceptible to ſight*. The account is by much too long for a work like ours; eſpecially as we feel not ourſelves inclined to attribute to the experiments all the importance which ſeems to have been allowed to them by the firſt claſs of the French National Inſtitute. We ſhall therefore ſtate only a few of them, which ſeem moſt to favour the author's hypotheſis.

1. A concrete odorant ſubſtance, laid upon a wet glaſs or broad ſaucer, covered with a thin ſtratum of water, immediately cauſes the water to recede, ſo as to form a ſpace of ſeveral inches around it.

2. Fragments of concrete odorant matter, or ſmall morſels of paper or cork, impregnated with an odorant liquor, and wiped, being placed on the ſurface of water, are immediately moved by a very ſwift rotation. Romieu had made this obſervation on camphor, and erroneouſly attributed the effect to electricity. The motion was perceptible even in pieces of camphor of ſeven or eight gros.

3. An odorant liquor being poured on the water, ſtops the motion till it is diſſipated by evaporation. Fixed oil arreſts the motion for a much longer time, and

and until the pellicle it forms on the water is taken off.

4. When the ſurface of the water is cleaned by a leaf of metal, of paper, or of glaſs, plunged in and withdrawn ſucceſſively until the pellicle is removed, the gyratory motion is renewed. If a piece of red wax or of taper be dipped in water, and the drops ſhaken off into a glaſs of water containing odorant bodies in motion, the movement will be ſtopped. The ſame effect is not produced by metal.

5. A morſel of camphor, plunged to the depth of three or four lines in water, without floating, excites a movement of trepidation in the ſurrounding water, which repels ſmall bodies in its vicinity, and carries them again to the camphor by ſtarts. The author concludes, that an elaſtic fluid eſcapes from the odorant body in the manner of the fire of a fuſee or the diſcharge of fire-arms.

6. When there is a certain proportion between the height of the water and that of the ſmall fragment of camphor, the water is briſkly driven off, returns again to the camphor, and again retires, as if by an exploſion, the recoil of which often cauſes the camphor to make part of a revolution on its axis.

7. Camphor evaporates thirty or forty times more ſpeedily when placed upon water, than when entirely ſurrounded with air.

8. Camphor, during the act of diſſipation in the air, preſerves its form and its opaque whiteneſs; upon water it is rounded, and becomes tranſparent as if it had undergone a kind of fuſion. It may be inferred, that this ariſes from the acquired motion, which cauſes it to preſent a greater ſurface to the air.

9. When ſmall pieces of camphor are plunged in water, the camphor becomes rounded and tranſparent, does not acquire any motion, and its diſſipation is leſs perceptible than in the air. The concurrence of air and water is therefore neceſſary to diſengage the fluid which is the cauſe of the motion and total diſſipation of odorant bodies.

10. The motion of odorant bodies upon water decays and ceaſes ſpontaneouſly at the end of a certain time; becauſe the water having then contracted a ſtrong ſmell, the volatilization takes place in all the points of its ſurface; and the ſmall maſs being thus ſurrounded by the odorant fluid, which is no longer air, diſſolves, as in the ordinary odorant fluids, without forming the gaſeous jet which is the cauſe of the motion. The author compares the volatilization of the aromatic ſubſtance to a combuſtion excited by water.

M. Prevoſt hopes, that theſe, and other experiments which he explains, will contribute to the theory of odours, which ſo nearly reſembles that of the gaſes. He does not flatter himſelf with having exhauſted this ſubject, but conſiders his diſcoveries as the means of rendering odour perceptible by water, not only to the ſight, but even to the touch, as are likewiſe the vibrations of ſonorous bodies. Men deprived of the ſenſe of ſmell, and even the blind, according to him, may in this manner diſtinguiſh odorant bodies from thoſe which have no ſmell. "Perhaps (ſays he) this kind of odoroſcope may, by improvement, become an odorimeter. The exceptions, ſuch for example as that of the cerumen of the ears, which produces much effect on water without being perceptibly odorant, and that of the fingers when hot or moiſt, are merely apparent; for if our ſenſes do not in thoſe caſes diſcover odour, thoſe of animals more powerfully energetic, ſuch as the dog, perceive and diſtinguiſh individuals by its peculiar character. The odoroſcope may afford the information which is wanting reſpecting theſe effluvia. Thus it is that the fat of game, the ſmell of which is nearly to us imperceptible, is very much ſo to dogs, and exhibits ſenſible marks by the odoroſcope."

Profeſſor Venturi of Modena, who heard Prevoſt's memoir read in the National Inſtitute, had himſelf made ſome experiments with camphor kept ſeparately in the air, in the water, and at the ſurface of the water; whence he deduces, that the moſt active virtue for diſſolving camphor reſides at that part where both the air and the water touch the camphor at the ſame time. Hence he explains why, in like circumſtances, camphor evaporates more quickly in a moiſt than in a dry air; and why the Hollanders uſe water in their proceſs for ſubliming this ſubſtance.

It might be thought that the camphor was decompoſed at the ſurface of the water; that the water might ſeize the acidifying part, which renders the camphor concrete; and that the volatile part is diſſipated in the atmoſphere. The author rejects this notion. He thinks that water with camphor floating on its ſurface becomes charged with no more than a very ſmall portion: 1. Becauſe in theſe circumſtances the water acquires the ſame taſte and ſmell of camphor as it obtains when a ſmall quantity of this ſubſtance is kept plunged in the ſame fluid. This water, by expoſure to the air, loſes the qualities with which it had been charged, and becomes inſipid, and without ſmell. 2. Becauſe when the water is ſaturated with all it can take up, the diſſipation of the camphor continues at its ſurface as before. 3. Becauſe the aerial emanations of camphor made at the ſurface of water do themſelves cryſtallize into camphor.

Camphor at the ſurface of the water does nothing, therefore, but diſſolve; and when diſſolved at the ordinary temperature of the atmoſphere, it is not at firſt in the ſtate of vapour, as has been thought. It is ſimply a liquid which extends itſelf over the ſurface of water itſelf; and by this means coming into contact with a great ſurface of air, it is afterwards abſorbed and evaporated. This is proved by the following facts: 1. The ſolution of camphor at the ſurface of water is more rapid in proportion to the extent of the ſurface. In narrow veſſels, the ſection of the column would not be completed in ten days, even though the water might be extremely pure. 2. When the column of camphor has projecting parts, the liquid may be ſeen iſſuing by preference from certain points of the column, covering the ſurface of the water, and driving ſmall floating bodies before it, in the ſame manner as floating bodies go and return in a baſon into which the water of a canal enters with rapidity. 3. If a ſmall piece of camphor, already wetted at one end, be brought near the edge of water contained in a broad ſaucer, and be made to touch the ſaucer itſelf, it depoſits a viſible liquor, which is oily; and by attaching itſelf to the ſaucer, deſtroys the adheſion between the veſſel and the border of the water, ſo that the water retires on account of the affinity of aggregation, which not being oppoſed by the attraction of the ſaucer, cauſes the water to terminate in a round edge. If you remove the piece of camphor, the water will not return to its place until the oily fluid is evaporated. 4. In the ſame manner, when the column of camphor is half immerſed in the water, the oily liquor which iſſues forth deſtroys the adheſion of the water to the column, and produces a ſmall ſurrounding cavity. The ſolution ſtops, or is retarded for a moment, until the fluid, extending itſelf over the water, becomes evaporated: the water then returns to its place, and touches the ſame part of the camphor; the ſolution begins again, and in this manner the proceſs is effected by alternations of contact and apparent repulſion.

Of theſe memoirs by Prevoſt and Venturi, the Engliſh reader will find accurate and full tranſlations in the firſt volume of *Nicholſon's Philoſophical Journal*, together with ſome judicious obſervations on them by the editor, which we ſhall take the liberty to adopt. "The philoſophical conſideration of odorant bodies is ſomewhat obſcured by the old method of generaliſing, or referring the properties of bodies to ſome diſtinct principle or thing ſuppoſed capable of being ſeparated from the body itſelf. Thus the odours of bodies have been ſuppoſed to depend on a ſubſtance imagined in a looſe way to be common to them all and ſeparable from them. Hence the terms, principle of ſmell, ſpiritus rector, and even in the modern nomenclature we find *aroma*. There does not in effect ſeem to be any more reaſon to infer the exiſtence of a common principle of ſmell than of taſte. The ſmell of ammoniac is the action of that gas upon the organ of ſenſe; and this odorant inviſible matter is exhibited to the ſight when combined with an acid gas. But in the ſame manner as ammoniac emanates from water, and leaves moſt part of that fluid behind, ſo will the volatile parts of bodies be moſt eminently productive of this action; and very few, if any, natural bodies will be found which riſe totally. The moſt ſtriking circumſtance in the effect is, that an act of ſuch power ſhould be attended with a loſs by exhalation which is ſcarcely to be appreciated by weight, or in any other method during a ſhort interval of time. But we know ſo little of nervous action, and of other phenomena of electricity, of galvaniſm (See GALVANISM in this *Suppl.*), or even of heat, which ſtrongly affect the ſenſes, but elude admeaſurement by gravitation, that the difficulty of weighing the effluvia of odorant bodies becomes leſs aſtoniſhing."

ŒCONOMISTS, a ſect of philoſophers in France, who have made a great noiſe in Europe, and are generally believed to have been unfriendly to religion. The founder of this ſect was a *Dr Duqueſnai*, who had ſo well inſinuated himſelf into the favour of Louis XV. that the king uſed to call him his *thinker*. The ſect was called *œconomiſts*, becauſe the œconomy and order to be introduced into the finances, and other means of alleviating the diſtreſſes of the people, were perpetually in their mouths. The Abbé Barruel admits, that there may have been ſome few of them who directed their ſpeculations to no other object; but he brings very ſufficient proof that the great aim of the majority of the ſect was to eradicate from the minds of the people all reverence for divine revelation.

"Duqueſnai (ſays he) and his adepts had more eſpecially undertaken to perſuade their readers, that the country people, and mechanics in towns, were entirely deſtitute of that kind of inſtruction neceſſary for their profeſſions; that men of this claſs, unable to acquire knowledge by reading, pined away in an ignorance equally fatal to themſelves and to the ſtate; that it was neceſſary to eſtabliſh free ſchools, and particularly throughout the country, where children might be brought up to different trades, and inſtructed in the principles of agriculture. D'Alembert, and the Voltairean adepts, ſoon perceived the advantages they could reap from theſe eſtabliſhments. In union with the œconomiſts, they preſented various memorials to Louis XV. in which not only the temporal but even the ſpiritual advantages of ſuch eſtabliſhments for the people are ſtrongly urged. The king, who really loved the people, embraced the project with warmth. He opened his mind on the ſubject to Mr Bertin, whom he honoured with his confidence, and had entruſted with his privy purſe;" and it was with great difficulty that this miniſter could convince him of the dangerous deſigns of the ſect.

"Determined (ſays he) to give the king poſitive proof that the œconomiſts impoſed upon him, I ſought to gain the confidence of thoſe pedlars who travel through the country, and expoſe their goods to ſale in the villages, and at the gates of country ſeats. I ſuſpected thoſe in particular who dealt in books to be nothing leſs than the agents of philoſophiſm with the good country folks. In my excurſions into the country I fixed my attention above all on the latter. When they offered me a book to buy, I queſtioned them what might be the books they had? Probably catechiſms or prayer-books? Few others are read in the villages? At theſe words I have ſeen many ſmile. No, they anſwered, thoſe are not our works; we make much more money of Voltaire, Diderot, and other philoſophic writings. What! ſaid I; the country people buy Voltaire and Diderot? Where do they find the money for ſuch dear works? Their conſtant anſwer was, we have them at a much cheaper rate than prayer-books; we can ſell them at ten ſols (5d.) a volume, and have a pretty profit into the bargain. Queſtioning ſome of them ſtill farther, many of them owned that thoſe books coſt them nothing; that they received whole bales of them without knowing whence they came, but being ſimply deſired to ſell them in their journeys at the loweſt price."

"Louis XV. warned by the diſcovery made by his miniſter, was at length ſatisfied that the eſtabliſhment of theſe ſchools, ſo much urged by the conſpirators, would only be a new inſtrument of ſeduction in their hands. He abandoned the plan; but, perpetually haraſſed by the protecting ſophiſters, he did not ſtrike at the root of the evil, and but feebly impeded its progreſs. The pedlars continued to promote the meaſures of the conſpirators; yet this was but one of the inferior means employed to ſupply the want of their free ſchools, as a new diſcovery brought to light one far more fatal.

"About the middle of the month of September 1789, little more than a fortnight antecedent to the atrocious 5th and 6th of October, at a time when the conduct of the National Aſſembly, having thrown the people into all the horrors of a revolution, indicated that they would ſet no bounds to their pretenſions, Mr Le Roy, lieutenant of the King's Hunt, and an academician, being at dinner at the houſe of Mr D'Angevilliers, intendant of the buildings of his majeſty, the

Œconomiſts.

converſation turned on the diſaſters of the revolution, and on thoſe that were too clearly to be foreſeen. Dinner over, the nobleman above-mentioned, a friend of Le Roy, hurt at having ſeen him ſo great an admirer of the ſophiſters, reproached him with it in the following expreſſive words: *Well! this, then, is the work of Philoſophy!* Thunderſtruck at theſe words—Alas! cried the academician, *to whom do you ſay ſo? I know it but too well, and I ſhall die of grief and remorſe!* At the word *remorſe*, the ſame nobleman queſtioned him whether he had ſo greatly contributed towards the revolution as to upbraid himſelf with it in that violent manner? 'Yes (anſwered he), I have contributed to it, and far more than I was aware of. I was ſecretary to the committee to which you are indebted for it; but I call heaven to witneſs, that I never thought it would go to ſuch lengths. You have ſeen me in the king's ſervice, and you know that I love his perſon. I little thought of bringing his ſubjects to this pitch, *and I ſhall die of grief and remorſe!*'

" Preſſed to explain what he meant by this committee, this ſecret ſociety, entirely new to the whole company, the academician reſumed: 'This ſociety was a ſort of club that we philoſophers had formed among us, and only admitted into it perſons on whom we could perfectly rely. Our ſittings were regularly held at the Baron D'Holbach's. Leſt our object ſhould be ſurmiſed, we called ourſelves œconomiſts. We created Voltaire, though abſent, our honorary and perpetual preſident. Our principal members were D'Alembert, Turgot, Condorcet, Diderot, La Harpe, and that Lamoignon, keeper of the ſeals, who on his diſmiſſion ſhot himſelf in his park.'

" The whole of this declaration was accompanied with tears and ſighs; when the adept, deeply penitent, continued: 'The following were our occupations; the moſt of thoſe works which have appeared for this long time paſt againſt religion, morals, and government, were ours, or thoſe of authors devoted to us. They were all compoſed by the members or by the orders of the ſociety. Before they were ſent to the preſs, they were delivered in at our office. There we reviſed and corrected them; added to, or curtailed them, according as circumſtances required. When our philoſophy was too glaring for the times, or for the object of the work, we brought it to a lower tint; and when we thought that we might be more daring than the author, we ſpoke more openly. In a word, we made our writers ſay exactly what we pleaſed. Then the work was publiſhed under the title or name we had choſen, the better to hide the hand whence it came. Many, ſuppoſed to have been poſthumous works, ſuch as *Chriſtianity Unmaſked*, and divers others *attributed to Freret and Boulanger* after their deaths, were iſſued from our ſociety.

'When we had approved of thoſe works, we began by printing them on fine or ordinary paper, in ſufficient number to pay our expences, and then an immenſe number on the commoneſt paper. Theſe latter we ſent to hawkers and bookſellers free of coſt, or nearly ſo, who were to circulate them among the people at the loweſt rate. Theſe were the means uſed to pervert the people, and bring them to the ſtate you now ſee them in. I ſhall not ſee them long, *for I ſhall die of grief and remorſe!*'

Oil.

This recital is too well authenticated to be called in queſtion, and too plain to need a commentary. Let it be a warning againſt all ſecret ſocieties, by whatever title of benevolence they may be deſigned by thoſe who form them.

OIL-MILL, a mill for expreſſing the oils from fruits, or grains, &c. As theſe kingdoms do not produce the olive, it would be needleſs to deſcribe the mills which are employed in the ſouthern parts of Europe. We ſhall content ourſelves, therefore, with a deſcription of a Dutch oil-mill, employed for grinding and preſſing lintſeed, rape-ſeed, and other oleaginous grains. Farther, to accommodate our deſcription ſtill more to our local circumſtances, we ſhall employ water as the firſt mover; thus avoiding the enormous expence and complication of a windmill.

In Plate XXXVIII. fig. A,

1. Is the elevation of a wheel, over or underſhot, as the ſituation may require.
2. The bell-metal ſocket, ſupported by maſonry, for receiving the outer gudgeon of the water wheel.
3. The water courſe.

Fig B.

1. A ſpur wheel upon the ſame axis, having 52 teeth.
2. The trundle that is driven by N° 1. and has 78 ſtaves.
3. The *wallower*, or axis for raiſing the peſtles. It is furniſhed round its circumference with *wipers* for lifting the *peſtles*, ſo that each may fall twice during one turn of the water wheel, that is, three *wipers* for each peſtle.
4. A frame of timber, carrying a concave half cylinder of bell-metal, in which the wallower (caſed in that part with iron plates) reſts and turns round. It will be ſeen in profile, fig. G.
5. Maſonry ſupporting the inner gudgeon of the water wheel and the above-mentioned frame.
6. Gudgeon of the wallower, which bears againſt a bell-metal ſtep fixed in the wall. This double ſupport of the wallower is found to be neceſſary in all mills which drive a number of heavy ſtampers.

Fig. C, Is the elevation of the peſtle and preſs-frame, their furniture, the mortars, and the preſs-peſtles.

1. The ſix peſtles.
2. Croſs pieces between the two rails of the frame, forming, with theſe rails, guides for the perpendicular motion of the peſtles.
3. The two rails. The back one is not ſeen. They are checked and bolted into the ſtandards N° 12.
4. The tails of the *lifts*, correſponding to the wipers upon the wallower.
5. Another rail in front, for carrying the *detents* which hold up the peſtles when not acting. It is marked 14 in fig. M.
6. A beam a little way behind the peſtles. To this are fixed the pulleys for the ropes which lift and ſtop the peſtles. It is repreſented by 16 in fig. M.
7. The ſaid pulleys with their ropes.
8. The *driver*, which ſtrikes the wedge that preſſes the oil.
9. The *diſcharger*, a ſtamper which ſtrikes upon the inverted wedge, and looſens the preſs.

10. The lower rail with its croſs pieces, forming the lower guides of the peſtles.

11. A ſmall cog wheel upon the wallower, for turning the *ſpatula*, which ſtirs about the oil-ſeed in the *chauffer-pan*. It has 28 teeth, and is marked Nº 6. in fig. M.

12. The four ſtandards, mortiſed below into the *block*, and above into the joiſts and beams of the building.

13. The ſix *mortars* hollowed out of the block itſelf, and in ſhape pretty much like a kitchen pot.

14. The feet of the peſtles, rounded into cylinders, and ſhod with a great lump of iron.

15. A board behind the peſtles, ſtanding on its edge, but inclining a little backwards. There is ſuch another in front, but not repreſented here. Theſe form a ſort of trough, which prevents the ſeed from being ſcattered about by the fall of the peſtles, and loſt.

16. The firſt *preſs-box* (alſo hollowed out of the block), in which the grain is ſqueezed, after it has come for the firſt time from below the milſtones.

17. The ſecond *preſs-box*, at the other end of the block, for ſqueezing the grain after it has paſſed a ſecond time under the peſtles.

18. Frame of timber for ſupporting the other end of the wallower, in the ſame manner as at Nº 4. fig. B.

19. Small cog wheel on the end of the wallower for giving motion to the milſtones. It has 28 teeth.

20. Gudgeon of the wallower, bearing on a bell metal ſocket fixed in the wall.

21. Veſſels for receiving the oil from the preſs-boxes.

22. Joiſts ſupporting the block.

Fig. D. Elevation and mechaniſm of the milſtones.

1. *Upright ſhaft*, carrying the great cog wheel above, and the *runner milſtones* below in their frame.

2. Cog-wheel of 76 cogs, driven by Nº 19. of fig. C.

3. The frame of the *runners*. This will be more diſtinctly underſtood in Nº 4. fig. H.

4. The innermoſt runner, or the one neareſt the ſhaft.

5. Outermoſt ditto, being farther from the ſhaft.

6. The *inner rake*, which collects the grain under the outer runner.

7. The *outer rake*, which collects the grain under the inner runner. In this manner the grain is always turned over and over, and cruſhed in every direction. The inner rake lays the grain in a ſlope, of which fig. O. is a ſection; the runner flattens it, and the ſecond rake lifts it again, as is marked in fig. P.; ſo that every ſide of a grain is preſented to the milſtone, and the reſt of the *legger* or *nether milſtone* is ſo ſwept by them, that not a ſingle grain is left on any part of it. The outer rake is alſo furniſhed with a rag of cloth, which rubs againſt the border or hoop that ſurrounds the nether milſtone, ſo as to drag out the few grains which might otherwiſe remain in the corner.

8. The ends of the iron axle which paſſes through the upright ſhaft, and through the two runners. Thus they have two motions: 1*mo*, A rotation round their own axis. 2*do*, That by which they are carried round upon the nether milſtone on which they roll. The holes in theſe milſtones are made a little widiſh; and the holes in the ears of the frame, which carry the ends of the iron axis, are made oval up and down. This great freedom of motion is neceſſary for the runner milſtones, becauſe frequently more or leſs of the grain is below them at a time, and they muſt therefore be at liberty to get over it without ſtraining, and perhaps breaking, the ſhaft.

9. The ears of the frame which lead the two extremities of the iron axis. They are mortiſed into the under ſide of the bars of the ſquare frame, that is carried round with the ſhaft.

10. The border or hoop which ſurrounds the nether milſtone.

11. and 12. The nether milſtone and maſonry which ſupports it.

Fig. E. Form of the wallower, ſhewing the diſpoſition of the wipers along its ſurface.

1. Two parts of this ſhaft, which are nicely rounded, and fortified with iron plates, and which reſt upon the bell-metal concaves, which are repreſented in nº 4. of fig. C.

2. The little wheels at each end, for giving motion to the two ſpatulæ, marked nº 11. fig. C.

3. The wipers for the ſecond preſs.

4. The wipers for the firſt preſs.

5. The wipers for the ſix peſtles.

Fig. F. Repreſents the ſurface of the wallower unfolded into a rectangular parallelogram, in order to ſhew the diſtribution of the wipers, and conſequently the ſucceſſion of the ſtrokes given by the different peſtles. This diſtribution has ſomething peculiar. Each peſtle has three wipers; and there are alſo three for the driver and diſcharger of the ſecond preſs. The driver and wiper of the firſt preſs have but one and a half; one for the driver, and the half for the diſcharger; ſo that it ſtrikes twice, and the driver only once, in a turn of the ſhaft. This is the Dutch practice, which differs from that of Flanders. The ſucceſſion of the ſtrokes may be conceived as follows: Reckon the ſtampers, including thoſe of the preſſes, from the water wheel toward the other end of the wallower, and calling them *a, b, c, d, e, f, g, h, i, k*, and ſuppoſing that *a* makes the firſt ſtroke, they proceed in the following order for one turn of the wallower:

ab, d, f, h, c, e, g, ab, d, f, h, c, e, g, ab, d, f, h, c, e, g.

Here it may be obſerved that *a* and *b* ſtrike together. They would do ſo if allowed; but one of them is held up by its detent till the workman ſees proper to diſengage it. Each peſtle, and the driver and diſcharger of the ſecond preſs, makes three ſtrokes for one turn of the wallower. But the driver *k* of the firſt preſs makes only one ſtroke in that time, namely, in the interval between the laſt ſtrokes of *e* and *g*. The diſcharger *i* of this preſs makes two ſtrokes; one of them in this ſame interval, and the other along with the firſt ſtroke of *e*. The ſecond preſſing requires a much more violent preſſure than the firſt, becauſe the cake muſt be left perfectly dry and hard.

Fig. G. Profile of the frame of timber which carries the wallower, and greatly contributes to render its motion ſteady.

Fig. H. Is a view of one of the milſtones.

1. The nether milſtones, and the maſonry ſupporting the whole.

2. The runner.

3. A ſort of caſe which encloſes the two wings of the milſtone at a very ſmall diſtance from it, in order to prevent the grain which ſticks to it from being ſcattered. There is another method practiſed at ſome mills.

Fig. I. Repreſents that of Sardamm. AA are two iron rods, about half an inch ſquare, hanging on the axle, on each ſide of the milſtone. Theſe rods are joined by a croſs piece C, which almoſt touches the milſtone. A piece of leather is put between, which rubs upon the milſtone, and clears it of the grain which chances to ſtick to it. N° 4. and 6. repreſent the ears of this frame, by which the end of the iron axle is ſupported, and carried round by the upright ſhaft n° 5.

Fig. K. Plan of the runner milſtones, and the frame which carries them round.

1, 1. Are the two milſtones.

3, 3, 3, 3. The outſide pieces of the frame.

4, 4, 4, 4. The croſs bars of the frame which embrace the upright ſhaft 5, and give motion to the whole.

6, 6. The iron axis upon which the runners turn.

7. The outer rake.

8. The inner ditto.

Fig. L. Repreſents the nether milſtone ſeen from above.

1. The wooden gutter, which ſurrounds the nether milſtone.

2. The border or hoop, about ſix inches high, all round, to prevent any ſeed from being ſcattered.

3. An opening or trap-door in the gutter, which can be opened or ſhut at pleaſure. When open, it allows the bruiſed grain, collected in and ſhoved along the gutter by the rakes, to paſs through into troughs placed below to receive it.

4. Portion of the circle deſcribed by the outer runner.

5. Portion of the circle deſcribed by the inner one. By theſe we ſee that the two ſtones have different routes round the axis, and bruiſe more ſeed.

6. The outer rake.

7. The inner ditto.

8. The ſweep, making part of the inner rake, occaſionally let down for ſweeping off all the ſeed when it has been ſufficiently bruiſed. The preſſure and action of theſe rakes is adjuſted by means of wooden ſprings, which cannot be eaſily and diſtinctly repreſented by any figure. The oblique poſition of the rakes (the outer point going foremoſt) cauſes them to ſhove the grain inwards or toward the centre, and at the ſame time to turn it over, ſomewhat in the ſame manner as the mould-board of a plough ſhoves the earth to the right hand, and partly turns it over. Some mills have but one ſweeper; and, indeed, there is great variety in the form and conſtruction of this part of the machinery.

Fig. M. Profile of the peſtle frame.

1. Section of the horizontal ſhaft.

2. Three wipers for lifting the peſtles.

3. Little wheel of 28 teeth for giving motion to the ſpatula.

4. Another wheel, which is driven by it, having 20 teeth.

5. Horizontal axle of ditto.

6. Another wheel on the ſame axle, having 13 teeth.

7. A wheel upon the upper end of the ſpindle, having 12 teeth.

8. Two guides, in which the ſpindle turns freely, and ſo that it can be ſhifted higher and lower.

9. A lever, moveable round the piece n° 14. and having a hole in it at 9, through which the ſpindle paſſes, turning freely. The ſpindle has in this place a ſhoulder, which reſts on the border of the hole 9; ſo that by the motion of this lever the ſpindle may be diſengaged from the wheel work at pleaſure. This motion is given to it by means of the lever 10, 10, moveable round its middle. The workman employed at the chauffer pulls at the rope 10, 11, and thus diſengages the ſpindle and ſpatula.

11. A peſtle ſeen ſidewiſe.

12. The *liſt* of ditto.

13. The upper rails, marked n° 3. in fig. C.

14. The rail, marked n° 5. in fig C. To this are fixed the detents, which ſerve to ſtop and hold up the peſtles.

15. A detent, which is moved by the rope at its outer end.

16. A bracket behind the peſtles, having a pulley, through which paſſes the rope going to the detent 15.

17. The ſaid pulley.

18. The rope at the workman's hand, paſſing through the pulley 17, and fixed to the end of the detent 15.

This detent naturally hangs perpendicular by its own weight. When the workman wants to ſtop a peſtle, he pulls at the rope 18, during the riſe of the peſtle. When this is at its greateſt height, the detent is horizontal, and prevents the peſtle from falling by means of a pin projecting from the ſide of the peſtle, which reſts upon the detent, the detent itſelf being held in that poſition by hitching the loop of the rope upon a pin at the workman's hand.

19. The two lower rails, marked n° 10. fig. C.

20. *Great* wooden, and ſometimes ſtone, *block*, in which the mortars are formed, marked n° 21. in fig. C.

21. Veſſel placed below the preſs boxes for receiving the oil.

22. Chauffer, or little furnace, for warming the bruiſed grain.

23. Backet in the front of the chauffer, tapering downwards, and opening below in a narrow ſlit. The hair bags in which the grain is to be preſſed after it has been warmed in the chauffer, are filled by placing them in this backet. The grain is lifted out of the chauffer with a ladle, and put into theſe bags; and a good quantity of oil runs from it through the ſlit at the bottom into a veſſel ſet to receive it.

24. The ſpatula attached to the lower end of the ſpindle, and turning round among the grain in the chauffer-pan, and thus preventing it from ſticking to the bottom or ſides, and getting too much heat.

Fig. N. Plan of part of the works.

1, 1. Furnaces for warming the grain.

2, 2. The backets for holding the ſacks while they are a-filling.

3, 3. The pan in which the bruiſed grain is heated by the chauffer.

4, 4. A trough for receiving the chips, into which the preſſed oil-cakes are cut, to be afterwards put into the pan and warmed.

5. The preſs-box for the ſecond preſſing.

6. The preſs-box for the firſt preſſing.

7. The ſix mortars.

8. The ſloping boards, to hinder the ſcattering of the oil ſeed.

9. The nether milſtone, but out of its place.

10. Its centre a little higher than the reſt.

11. A rib of wood going round the edge of the nether milſtone, and even with its ſurface, but riſing a very little outwards, and ſurrounded with a border or hoop about an inch high, to prevent the ſeed from being ſcattered on the ground.

Fig. Q. A ſection, lengthwiſe, of the great block, with the mortars and preſs-boxes.

1. The ſix peſtles.

2. The ſix mortars, each of which has an iron plate at its bottom.

3. The *driving* ſtamper, which falls on the wedge of the firſt preſſing.

4. Ditto, for the ſecond ditto.

5. The *diſcharger*, which ſtrikes on the inverted wedge in order to free the preſs.

6. Ditto, for the ſecond preſſing.

7. Wedge for freeing the preſs.

8. Wedge for preſſing.

9. Wooden *cheeks*, two inches thick, which are placed between the middle wedge and the *ſliding wedges* on each ſide.

10. Preſs-irons, between which are placed the hair-bags containing the bruiſed grain.

11. Iron plate, called the *fountain*, at the bottom, pierced with holes, correſponding with a hole in the block, for allowing the oil to run off from the preſſed grain.

12. Veſſel for receiving ditto.

13. A long iron plate at the bottom of the preſs box, under the drawing and diſcharging wedges.

Fig. R. Another view of the preſs-irons.

1. The ſide-irons laid flat.

2. The ſame ſeen edgewiſe.

3. The pierced iron plate, upon which the two irons, nº 1. ſtand upright, with the hair-bag between them.

4. One of the hair-bags. It may be obſerved that the ſeams of theſe bags are made on the flat ſides, and not on the edges, where they would be in danger of burſting.

5. A long hair-cloth, in which the bag is wrapped before it is ſet into the preſs. The bag, being filled with bruiſed grain, is placed with its bottom at *a*, and the top at *b*; the part *c a* is lapped over it, reaching to *b*, and then the other end *d* is lapped over that, and reaches to *a*, and the loop at its end ſerves as a handle by which to lift it, and place it properly between the preſs-irons.

Fig. S. The principal pieces of the preſs.

1. The wooden cheeks.

2. The diſcharging wedge.

3. The driving wedge.

4 and 5. The ſliding blocks, which tranſmit the preſſure produced by the driving wedge.

The foregoing enumeration and views of the different parts of a Dutch oil-mill, are ſufficient, we imagine, to enable an intelligent mill-wright, to whom the machine is altogether new, to underſtand its manner of working, and its adaptation to the various parts of the proceſs for extracting the oil from ſeeds or kernels. It would require a very minute deſcription indeed to explain it to a perſon altogether unacquainted with mill-work.

The firſt part of the proceſs is bruiſing the ſeed under the runner ſtones (A). That this may be more expeditiouſly done, one of the runners is ſet about ⅔ds of its own thickneſs nearer the ſhaft than the other. Thus they have different treads; and the grain, which is a little heaped towards the centre, is thus bruiſed by both. The inner rake gathers it up under the outer ſtone into a ridge, of which the ſection is repreſented in Plate XL. fig. O. The ſtone paſſes over it and flattens it. It is gathered up again into a ridge, of the form of fig. P. under the inner ſtone, by the outer rake, which conſiſts of two parts. The outer part preſſes cloſe on the wooden border which ſurrounds the nether ſtone, and ſhoves the ſeed obliquely inwards, while the inner part of this rake gathers up what had ſpread toward the centre. The other rake has a joint near the middle of its length, by which the outer half of it can be raiſed from the nether ſtone, while the inner half continues preſſing on it, and thus ſcrapes off the moiſt paſte. When the ſeed is ſufficiently bruiſed, the miller lets down the outer end of the rake. This immediately gathers the whole paſte, and ſhoves it obliquely outwards to the wooden rim, where it is at laſt brought to a part that is left unboarded, and it falls through into troughs placed to receive it. Theſe troughs have holes in the bottom, through which the oil drips all the time of the operation. This part of the oil is directed into a particular ciſtern, being conſidered as the pureſt of the whole, having been obtained, without preſſure, by the mere breaking of the hull of the ſeed.

In ſome mills this operation is expedited, and a much greater quantity of this beſt oil is obtained, by having the bed of maſonry which ſupports the legger formed into a little furnace, and gently heated. But the utmoſt care is neceſſary to prevent the heat from becoming conſiderable. This, enabling the oil to diſſolve more of the fermentable ſubſtance of the ſeed, expoſes the oil to the riſk of growing ſoon very rancid; and, in general, it is thought a hazardous practice, and the oil does not bring ſo high a price.

When the paſte comes from under the ſtones, it is put into the hair bags, and ſubjected to the firſt preſſing. The oil thus obtained is alſo eſteemed as of the firſt quality, ſcarcely inferior to the former, and is kept apart (The great oil ciſtern being divided into ſeveral portions by partitions).

The oil cakes of this preſſing are taken out of the bags, broken to pieces, and put into the mortars for the firſt *ſtamping*. Here the paſte is again broken down, and the parenchyma of the ſeed reduced to a fine meal. Thus free egreſs is allowed to the oil from every veſicle in which it was contained. But it is now rendered much more clammy, by the forcible mixture of the mucilage,

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(A) We are told, that in a mill at Reichenhoffen in Alſace, a conſiderable improvement has been made by paſſing the ſeed between two ſmall iron rollers, before it is put under the milſtones. A great deal of work is ſaid to be ſaved by this preliminary operation, and finer oil produced, which we think very probable. The ſtamping and preſſing go on as in other mills.

cilage, and even of the finer parts of the meal. When ſufficiently pounded, the workman ſtops the peſtle of a mortar, when at the top of its lift, and carries the contents of the mortar to the firſt chauffer pan, where it is heated to about the temperature of melting bees wax (this, we are told, is the teſt), and all the while ſtirred about by the ſpatula. From thence it is again put into hair bags, in the manner already deſcribed; and the oil which drips from it during this operation is conſidered as the beſt of the ſecond quality, and in ſome mills is kept apart. The paſte is now ſubjected to the ſecond preſſing, and the oil is that of the ſecond quality.

All this operation of pounding and heating is performed by one workman, who has conſtant employment by taking the four mortars in ſucceſſion. The putting into the bags and conducting of the preſſing gives equal employment to another workman.

In the mills of Piccardy, Alſace, and moſt of Flanders, the operation ends here; and the produce from the chauffer is increaſed, by putting a ſpoonful or two of water into the pan among the paſte.

But the Dutch take more pains. They add no water to the paſte of this their *firſt ſtamping*. They ſay that this greatly lowers the quality of the oil. The cakes which reſult from this preſſing, and are there ſold as food for cattle, are ſtill fat and ſoftiſh. The Dutch break them down, and ſubject them to the peſtles for the *ſecond ſtamping*. Theſe reduce them to an impalpable paſte, ſtiff like clay. It is lifted out, and put into the *ſecond* chauffer pan; a few ſpoonfuls of water are added, and the whole kept for ſome time as hot as boiling water, and carefully ſtirred all the while. From thence it is lifted into the hare bags of the laſt preſs, ſubjected to the preſs; and a quantity of oil, of the loweſt quality, is obtained, ſufficient for giving a ſatisfactory profit to the miller. The cake is now perfectly dry, and hard, like a piece of board, and is ſold to the farmers. Nay, there are ſmall mills in Holland, which have no other employment than extracting the oil from the cakes which they purchaſe from the French and Brabanters; a clear indication of the ſuperiority of the Dutch practice.

The nicety with which that induſtrious people conduct all their buſineſs is remarkable in this manufacture.

In their oil ciſtern, the parenchymous part, which unavoidably gets through, in ſome degree, in every operation, gradually ſubſides, and the liquor, in any diviſion of the ciſtern, comes to conſiſt of ſtrata of different degrees of purity. The pumps which lift it out of each diviſion are in pairs; one takes it up from the very bottom, and the other only from half depth. The laſt only is barrelled up for the market, and the other goes into a deep and narrow ciſtern, where the dreg again ſubſides, and more pure oil of that quality is obtained. By ſuch careful and judicious practices, the Dutch not only ſupply themſelves with this important article, but annually ſend conſiderable quantities into the very provinces of France and Flanders where they bought the ſeed from which it was extracted. When we reflect on the high price of labour in Holland, on the want of timber for machinery, on the expence of building in that country, and on the enormous expence of wind mill machinery, both in the firſt erection and the ſubſequent wear and tear, it muſt be evident, that oil mills erected in England on water falls, and after the Dutch manner, cannot fail of being a great national advantage. The chatellanie or ſeigneurie of Lille alone makes annually between 30,000 and 40,000 barrels, each containing about 26 gallons.

What is here delivered is only a ſketch. Every perſon acquainted with machinery will underſtand the general movements and operations. But the intelligent mechanic well knows, that operations of this kind have many minute circumſtances which cannot be deſcribed, and which, nevertheleſs, may have a great influence on the whole. The rakes in the bruiſing-mill have an office to perform which reſembles that of the hand, directed by a careful eye and unceaſing attention. Words cannot communicate a clear notion of this; and a mill, conſtructed from the beſt drawings, by the moſt ſkilful workman, may gather the ſeed ſo ill, that the half of it ſhall not be bruiſed after many rounds of the machinery. This produces a ſcanty return of the fineſt oil; and the mill gets a bad character. The proprietor loſes his money, is diſcouraged, and gives up the work.—There is no ſecurity but by procuring a Dutch millwright, and paying him with the liberality of Britons. Such unhoped-for taſks have been performed of late years by machinery; and mechanical knowledge and *invention* is now ſo generally diffuſed, that it is highly probable that we ſhould ſoon excel our teachers in this branch. But this very diffuſion of knowledge, by encouraging ſpeculation among the artiſts, makes it a ſtill greater riſk to erect a Dutch oil mill without having a Dutchman, acquainted with its moſt improved preſent form, to conduct the work. We do our duty in giving this counſel.

OKU JESSO. See SEGALIEN in this *Suppl.*

OMPHALOPTER, or OMPHALOPTIC, in optics, a glaſs that is convex on both ſides, popularly called a *convex lens*.

ONISCUS (See *Encycl.*). Two new ſpecies of this genus of inſects were diſcovered by *La Martiniere*, the naturaliſt who accompanied Perouſe on his laſt voyage of diſcovery. For the information of ſuch of our readers as are entomologiſts, we ſhall give the author's deſcription of theſe ſpecies. Of the firſt, which he ſays only *nearly* anſwers to the *generic* character of oniſcus, E (fig. 1.) is a view of the upper part of its body, Plate XXXII. and at F of the lower. Its body is cruſtaceous, and of an opaque white, with two round ruſt-coloured ſpots on the anterior part of its corſlet; two others, much larger, in the form of a creſcent, are on the *elytra*; its ſhield is alſo of the ſame colour. The under part of the thorax is furniſhed with four pair of legs: the firſt and third of which are terminated with ſharp claws; the ſecond, from its form, ſerves it to ſwim with; the fourth is very ſmall, conſiſting of two membranaceous threads. Some ſcales, alſo membranaceous and very channelled, may alſo perform the office of legs: of theſe the two lower are the largeſt. Its belly is filled with vermicular inteſtines of the ſize of a hair; its mouth is placed between the firſt and ſecond pair of legs, and is of the form of a ſmall trunk placed between two lips, joined only at the upper extremity.

Fig. 2. repreſents an inſect of the genus *oniſcus Linn.* Its body is nearly of the form, conſiſtence, and colour, of the *oniſcus aſellus*, except that it is not divided

OIL MILL PLATE XXXVIII.

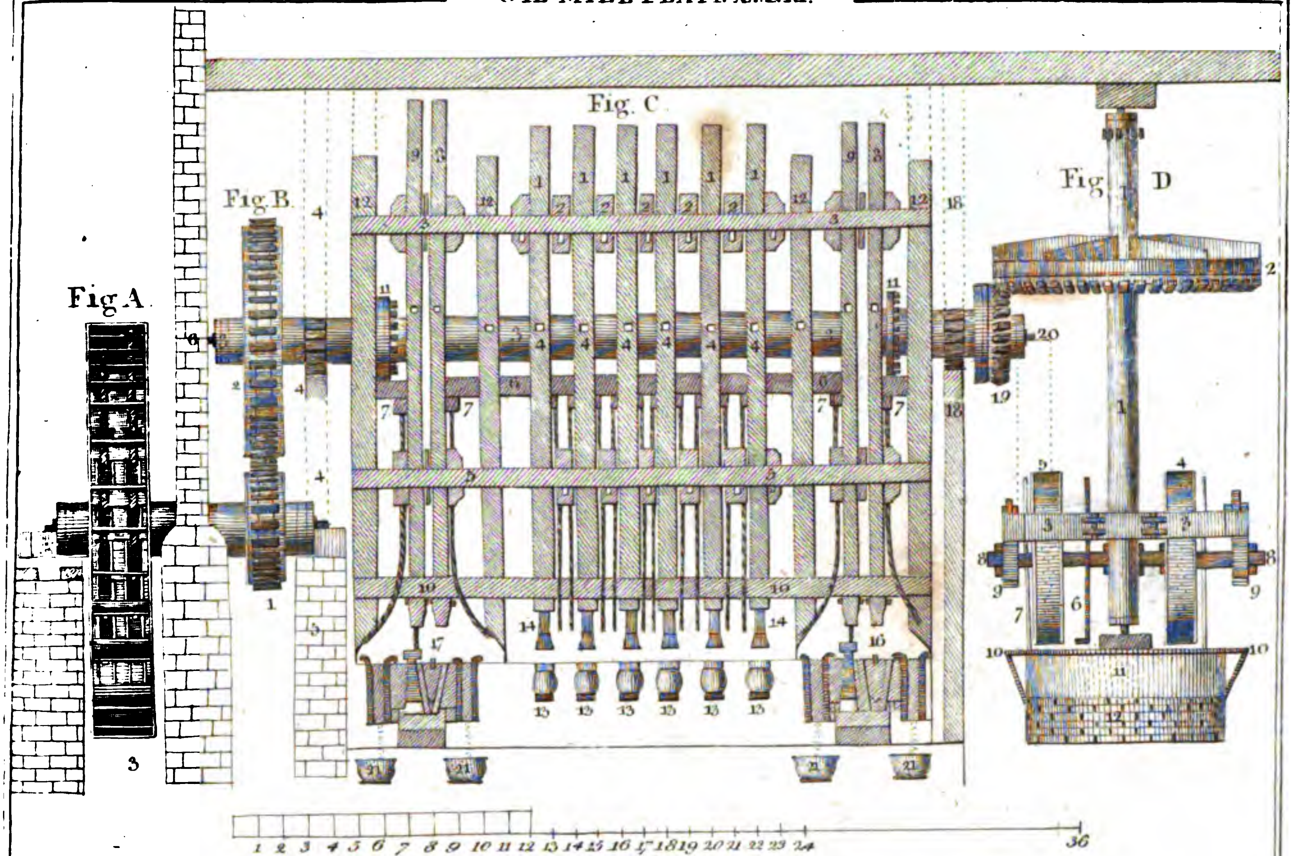


Fig. E.

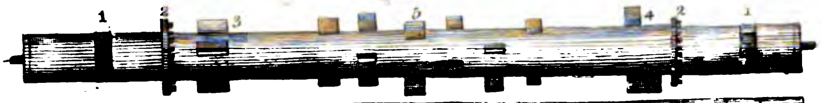


Fig F

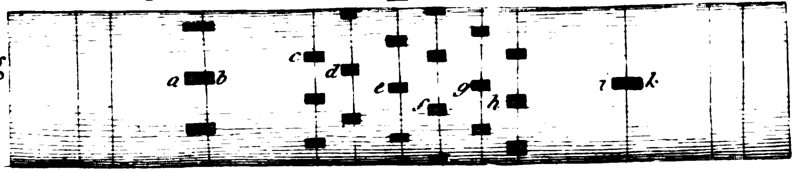


Fig K

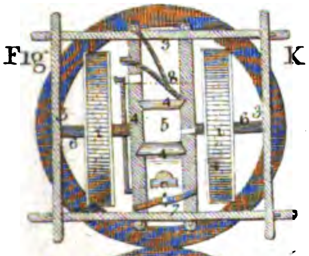


Fig L

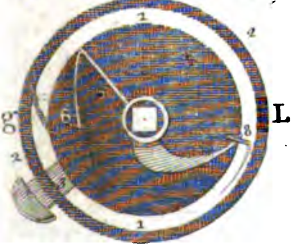


Fig H.

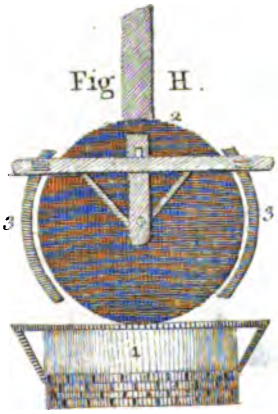


Fig. I.

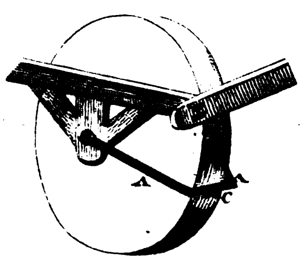
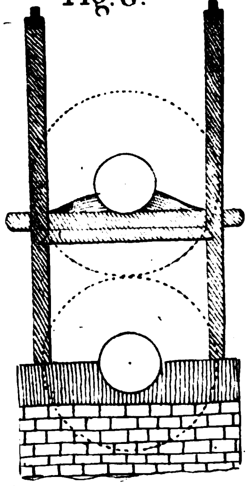
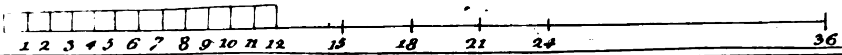


Fig. G.





[illegible] sculp

OIL MILL PLATE XXXIX.

Fig M.

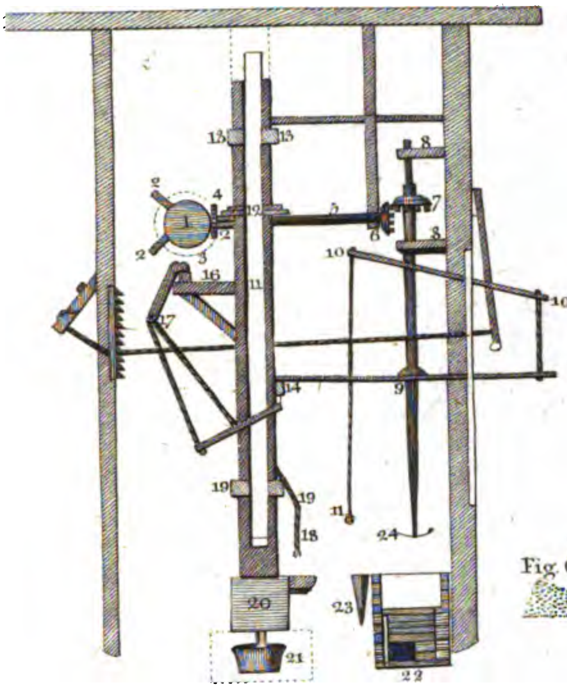


Fig. N.

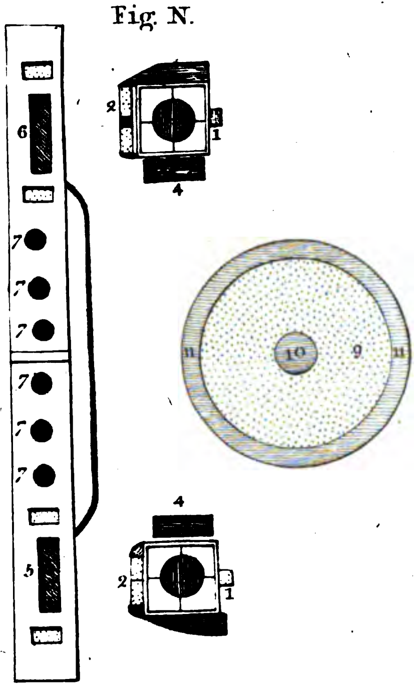


Fig. O.

Fig. P.

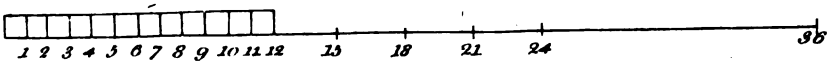


Fig. Q.

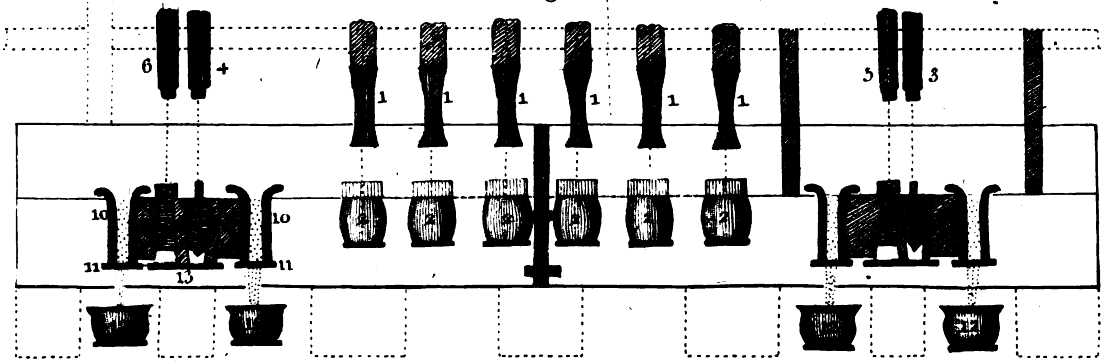


Fig. S.

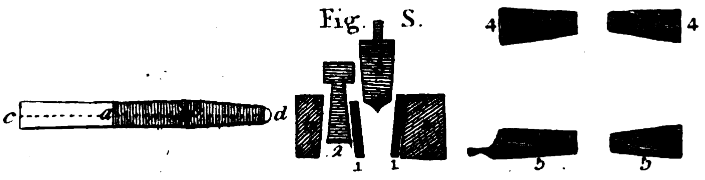
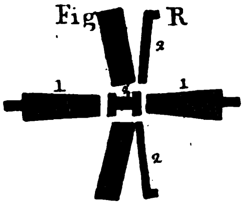
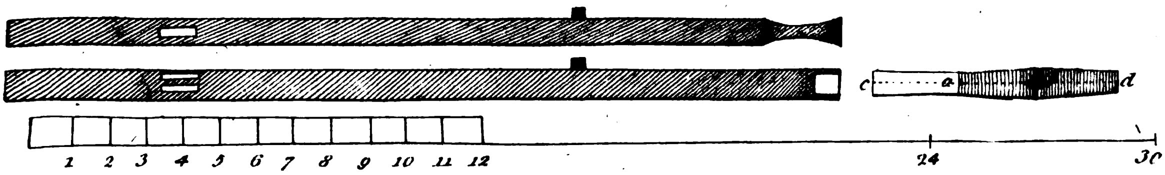


Fig. R





D.Lizars Sculpt.

vided by ſegments as this laſt is. It has a double tail, three times as long as the body; from the inſertion of which, at the hinder part of the body, ſpring two legs, uſed chiefly by the animal in ſwimming upon its back. The inſect, viewed on the lower part H, preſents ſix pair of legs; the two firſt of which terminate in very ſharp and thick points; it makes uſe of the third to ſwim with, and to balance its body, together with that pair which is inſerted at the baſe of the tail; the fourth pair, and the largeſt of all, is armed with two very ſharp points, which the animal forces into the body of any fiſh on which it ſeizes; the two laſt pair are nothing more than very finely divided membranes. Between the two firſt is ſituated its trunk, ſmooth, and about half a line long; at the baſe of the third pair are two points, of a horny conſiſtence, very hard, and firmly fixed. The two horns alſo below the large pair of legs are, in like manner, very firmly united to its body. Martiniere imagines it to be by means of theſe darts that it pierces the body of the fiſh on which it is found, and that then, changing its ſituation, it finds means to introduce its trunk into the holes thus formed. When put into a glaſs it ſinks to the bottom, and riſes again to the ſurface with the greateſt eaſe, advancing with the edge of its body, and deſcribing curves. Its two long tails are very eaſily pulled off, without the animal appearing to ſuffer any pain.

OPAQUE, not tranſlucent, nor tranſparent, or not admitting a free paſſage to the rays of light.

OPARO or Oparro, the name given by Captain Vancouver to a ſmall iſland which he diſcovered in latitude 27° 36′ ſouth, and in longitude 215° 49′ eaſt from Greenwich. It was eſtimated at about 6½ miles in length, and no other land was in ſight. Its principal character is a cluſter of high craggy mountains, forming, in ſeveral places, moſt romantic pinnacles, with perpendicular cliffs nearly from their ſummits to the ſea: the vacancies between the mountains would more properly be termed chaſms than valleys. The tops of ſix of the higheſt hills bore the appearance of fortified places, reſembling redoubts; having a ſort of blockhouſe, in the ſhape of an Engliſh glaſs-houſe, in the centre of each, with rows of palliſadoes a conſiderable way down the ſides of the hills, nearly at equal diſtances. Theſe overhanging, ſeemed intended for advanced works, and apparently capable of defending the citadel by a few againſt a numerous hoſt of aſſailants. On all of them people were noticed as if on duty, conſtantly moving about. What we conſidered (ſays the author) as block-houſes, from their great ſimilarity in appearance to that ſort of building, were ſufficiently large to lodge a conſiderable number of perſons, and were the only habitations we ſaw. Yet, from the number of canoes that in ſo ſhort a time aſſembled round the Engliſh ſhip, it is natural to conclude, that the inhabitants are very frequently afloat; and to infer, that the ſhores, and not thoſe fortified hills which appeared to be in the centre of the iſland, would be preferred for their general reſidence.

Whether the fortified places here deſcribed were intended for defences of the iſlanders againſt each other, or againſt attacks from ſome more powerful neighbours, could only be conjectured; but the latter idea ſeems the moſt probable. From the language of the people, and their reſemblance to the Friendly iſlanders, Captain Vancouver conſiders them all as having ſprung from the ſame original ſtock. The people of Oparo, however, are diſtinguiſhed by two circumſtances, certainly in their favour. Not one of them was tattowed; and though they appeared not to have ever ſeen a European before, they all ſeemed perfectly well acquainted with the uſes to which they could apply iron, and preferred articles of it to looking glaſſes, beads, and other trinkets, with which ſavages are uſually delighted. Though there appeared to be anchoring ground near the north-weſt end of the iſland, circumſtances rendered it inconvenient for Captain Vancouver to land on it; ſo that we are yet in a great meaſure ſtrangers to the diſpoſitions of the people, though they appeared to be hoſpitable.

OPEN Flank, in fortification, is that part of the flank which is covered by the orillon or ſhoulder.

OPENING *of the Trenches*, is the firſt breaking of ground by the beſiegers, in order to carry on their approaches towards a place.

OPERA-Glass, is a diagonal perſpective, of which the following conciſe and perſpicuous deſcription is taken from Dr Hutton's Mathematical Dictionary.—ABCD (Plate XLI.) repreſents a tube about four inches long; in each ſide of which there is a hole EF and GH, exactly againſt the middle of a plane mirror IK, which reflects the rays falling upon it to the convex glaſs LM; through which they are refracted to the concave eye-glaſs NO, whence they emerge parallel to the eye at the hole rs, in the end of the tube. Let PaQ be an object to be viewed, from which proceed the rays Pc, ab, and Qd: theſe rays, being reflected by the plane mirror IK, will ſhew the object in the direction cp, ba, dq, in the image pq, equal to the object PQ, and as far behind the mirror as the object is before it: the mirror being placed ſo as to make an angle of 45 degrees with the ſides of the tube. And as, in viewing near objects, it is not neceſſary to magnify them, the focal diſtances of both the glaſſes may be nearly equal; or, if that of LM be three inches, and that of NO one inch, the diſtance between them will be but two inches, and the object will be magnified three times, being ſufficient for the purpoſes to which this glaſs is applied.

When the object is very near, as XY, it is viewed through a hole xy, at the other end of the tube AB, without an eye-glaſs; the upper part of the mirror being poliſhed for that purpoſe as well as the under. The tube unſcrews near the object-glaſs LM, for taking out and cleanſing the glaſſes and mirror. The poſition of the object will be erect through the concave eye-glaſs.

The peculiar artifice of this glaſs is to view a perſon at a ſmall diſtance, ſo that no one ſhall know who is obſerved; for the inſtrument points to a different object from that which is viewed; and as there is a hole on each ſide, it is impoſſible to know on which hand the object is ſituated which you are viewing. It is chiefly uſed in play-houſes; and hence its name: but we have ſeen it moſt indecently employed by thoſe who ſhould have ſet a better example, even in a cathedral church!

OPHRYS (See *Encycl.*). A new ſpecies of this plant has been lately deſcribed in the *Annual Hampſhire Repoſitory*, by a Fellow of the Linnean Society, in the following words:

“ *Stem*—about 12 inches high, erect, ſtipulate, geniculate, pubeſcent at the upper genicles. *Spike*—ſtrictly ſpiral, flowers ſpirally aſcending, about 24, brightly white. Upper petal ovato acuminate, pubeſcent, lightly ciliate, ſtraight. Two middle *petals* oblong-recurved. Two lower *petals* oblong-acuminate, lightly ciliate only on the lower ſide near the baſe, projecting like elephant's tuſks. *Nectary*, broad, recurved, ragged, bicipitate. *Leaves floral*—carinate acuminate, ciliate reaching and pointing to the middle of the flowers. *Leaves radical*—five or ſix, about ſix inches long, narrow, attenuate both ways, acuminate, the lower more haſtate. *Leaves cauline*—lanceolate, alternate.

“ Obſervation.—This plant has much the habit, as well as autumnal floreſcence, of Oriental ſpiralis, and is ſo perfectly ſpiral alſo, that the ſpecific name of the other ſhould be altered, as being no longer excluſively ſpiral; at the ſame time that a ſpecific name ſhould be given to this: neither of which (ſays the author) I ſhall preſume to do, but ſhall ſuggeſt it to the Linnean Society, of which I have the honour to be a Fellow.”—This ophrys flowered, for the firſt time, it is believed, in England, in Hampſhire, October 1796.

OPHIUCUS, a conſtellation of the northern hemiſphere; called alſo *Serpentarius*.

OPIUM (See *Encycl.*), is a medicine of ſuch intrinſic value, and of ſo high a price, that every method which promiſes to increaſe the quantity in the market muſt be of importance. It was therefore, with much propriety, that *the Society for the Encouragement of Arts, &c.* ſome time ago, voted 50 guinneas to Mr John Ball of Williton, Somerſetſhire, for the diſcovery of his method of preparing opium from poppies of the growth of England. The poppies, which he recommends as the moſt productive, are the *double* or *ſemi-double*, of a dark colour; the ſeeds of which he adviſes to be ſown the latter end of February, and again about the ſecond week in March, in beds three feet and a half wide (well prepared with good rotten dung, and often turned or ploughed, in order to mix it well, and have it fine), either in ſmall drills, three in each bed, in the manner ſallads are ſown, and when about two inches high, to thin them one foot apart; or otherwiſe, to ſow them in beds, in the broad-caſt way, and thin them to the ſame diſtance. If they be kept free from weeds, they will grow well, and will produce from four to ten heads, ſhewing large and different coloured flowers; and when their leaves die away, and drop off, the pods then being in a green ſtate, is the proper time for extracting the opium, by making ſuch longitudinal inciſions as are, for this purpoſe, made in the eaſt (See OPIUM and PAPAVER, *Encycl.*). Immediately on the inciſion being made, a milky fluid will iſſue out; which is the opium, and which, being of a glutinous nature, will adhere to the bottom of the inciſion; but ſome poppies are ſo productive, that it will drop from the pod on the leaves underneath. The next day, if the weather ſhould be fine, and a good deal of ſunſhine, the opium will be found a greyiſh ſubſtance, and ſome almoſt turning black: it is then to be ſcraped from the pods, and (if any there) from the leaves, with the edge of a knife, or other inſtrument for that purpoſe, into pans or pots; and in a day or two it will be of a proper conſiſtence to make into a maſs, and to be potted.

According to Mr Ball, fields cannot be ſown with any thing more lucrative to the farmer than poppies, eſpecially if thoſe fields have a ſouth expoſure. “By a calculation (ſays he) which I have made, ſuppoſing one poppy to grow in one ſquare foot of earth, and to produce only one grain of opium, more than L. 50 will be collected from one ſtatute acre of land; but if we conſider, that one poppy produces from three or four to ten heads, that in each head from ſix to ten inciſions may be made, and that from many of them (I mean from one inciſion) I have taken away two or three grains of opium—What muſt then be the produce?”

Mr Ball produced to the Society letters from Dr Latham of Bedford-row, Dr Pearſon of Leiceſter-ſquare, and Mr Wilſon of Bedford-ſtreet, declaring, that, in their opinion, his Engliſh opium is equal in effect, and ſuperior in purity, to the beſt foreign opium.

OPTIC INEQUALITY, in aſtronomy, is an apparent irregularity in the motions of far diſtant bodies; ſo called, becauſe it is not really in the moving bodies, but ariſing from the ſituation of the obſerver's eye. For if the eye were in the centre, it would always ſee the motions as they really are.

OPTIC *Pyramid*, in perſpective, is a pyramid formed by the viſible object which is the *baſe*, and the rays drawn from the perimeter of that object, which meet at the eye in a point, which is the *apex* of the pyramid. Hence, alſo, we may know what is meant by an *optic triangle*.

OPTIC *Rays*, particularly means thoſe by which an optic pyramid, or optic triangle, is terminated.

ORAN, a conſiderable city, occupied by the Spaniards, in the province of *Maſcara*, in the country of Algiers. It has ſtrong and regular fortifications, and can eaſily be ſupplied from Spain with proviſions and warlike ſtores. It lies in 35′ of longitude weſt from Greenwich, and in 35° 55′ north latitude. Since the year 1732, the Spaniards have held uninterrupted poſſeſſion of Oran. It has a pariſh-church, three monaſteries, an hoſpital: and the number of the inhabitants, according to the account given of it by the Spaniards, amount to 12,000. Towards the ſea, the city riſes in the form of an amphitheatre, and is ſurrounded with forts and batteries. Cloſe to the city lies a ſtrong caſtle, *Alcazava*, in which the Spaniſh governor reſides. On the higheſt hill ſtands Fort St Croix, whoſe guns command the city and the adjacent country. From this fort they make ſignals of the approach of ſhips, and carefully watch the motions of the Moors, who often attempt predatory incurſions into the neighbouring diſtricts. A conſiderable number of Mahomedans take refuge in Oran; they dwell in a diſtinct part of the city, receive pay from the court of Spain, and render ſignal ſervices againſt the Moors. The greateſt part of the inhabitants of Oran conſiſts of ſuch as have been baniſhed from Spain; and the ſame may, in a great meaſure, be ſaid of the ſoldiers who compoſe the garriſon. Five regiments are commonly ſtationed here; but, owing to continual deſertion, their ſtrength ſcarcely equals that of four complete regiments. One of them wholly conſiſts of malefactors, who have been condemned to remain here for life; the reſt are ſuch as have been tranſported for one or more years. There is here likewiſe a military ſchool. Around the city are pleaſant gardens; but it is very dangerous to cultivate them, on account of the Moors and Arabs, who frequently lie in ambuſh among them. The ſame reaſon prevents the cultivation of the fields in the vicinity; and the garriſon

ſon and inhabitants muſt be ſupplied with proviſions immediately from Spain.

ORANGE-Men, an appellation aſſumed by certain ſocieties in Ireland, of which the firſt was formed in the county of Armagh, on the 21ſt of November 1795, others in ſome towns of Ulſter and Leinſter in the year 1797, another in the city of Dublin 1798; and ſince that period, theſe ſocieties have ſpread over the whole of our ſiſter kingdom. The object of theſe aſſociations is exhibited in the following authentic *Declaration of the Principles of Orange-men*, publiſhed 1799.

“From the various attempts that have been made to poiſon the public mind, and ſlander thoſe who have had the ſpirit to adhere to their king and conſtitution, and to maintain the laws:—

“We, the Proteſtants of Dublin, aſſuming the name of Orange-men, feel ourſelves called upon, not to vindicate our principles, for we know that our honour and loyalty bid defiance to the ſhafts of malevolence and diſaffection, but openly to avow thoſe principles, and declare to the world the objects of our inſtitution.

“We have long obſerved, with indignation, the efforts that have been made to foment rebellion in this kingdom, by the ſeditious, who have formed themſelves into ſocieties, under the ſpecious name of *United Iriſhmen*.

“We have ſeen with pain the lower orders of our fellow-ſubjects, forced or ſeduced from their allegiance, by the threats or machinations of *traitors*.

“And we have viewed with horror the ſucceſsful exertions of *miſcreants*, to encourage a foreign enemy to invade this happy land, in hopes of riſing into conſequence on the downfal of their country.

“We therefore thought it high time to rally round the conſtitution, and there pledge ourſelves to each other, to maintain the laws, and ſupport our good king againſt all his enemies, whether *rebels* to their God or to their country; and by ſo doing, ſhew to the world that there is a body of men in this iſland, who are ready, in the hour of danger, to ſtand forward in defence of that grand palladium of our liberties, the conſtitution of Great Britain and Ireland, obtained and eſtabliſhed by the courage and loyalty of our anceſtors under the Great King William.

“Fellow-ſubjects, we are accuſed with being an *inſtitution*, founded on principles too ſhocking to repeat, and bound together by oaths, at which human nature may ſhudder: but we caution you not to be led away by ſuch malevolent falſehoods; for we ſolemnly aſſure you, in the preſence of the Almighty God, that the idea of injuring any one, on account of his religious opinion, never entered into our *hearts*: we regard every loyal ſubject as our friend, be his religion what it may; we have no enmity but to the enemies of our country.

“We farther declare, that we are ready, at all times, to ſubmit ourſelves to the orders of thoſe in authority under his majeſty, and that we will cheerfully undertake any duty which they ſhall think proper to point out for us, in caſe either a foreign enemy ſhall dare to invade our coaſts, or that a domeſtic foe ſhall preſume to raiſe the ſtandard of rebellion in the land. To theſe principles we are pledged—and in ſupport of them we are ready to ſpend the laſt drop of our blood.—(Signed) Thomas Verner, *Grand Maſter*; John Clau. Beresford, *Grand Secretary*; William James, J. De Joncourt, Edward Ball.”

ORCHARD. As an appendix to this article in the *Encycl.* ſome of our readers will be pleaſed with the following means, employed by the Rev. Mr *Germerſhauſen*, for promoting the growth of young trees, and increaſing the ſize and flavour of the fruit in orchards.

Having planted ſeveral young plum-trees in an orchard, he covered the ground, for ſome years, around the trunks, as far as the roots extended, with flax-ſhows (A); by which means theſe trees, though in a graſs-field, increaſed in a wonderful manner, and far excelled others planted in cultivated ground. As far as the ſhows reached, the graſs and weeds were choaked; and the ſoil under them was ſo tender and ſoft, that no better mould could have been wiſhed for by a floriſt.

When he obſerved this, he covered the ground with the ſame ſubſtance, as far as the roots extended, around an old plum-tree, which appeared to be in a languiſhing ſtate, and which ſtood in a graſs-field. The conſequences were, that it acquired a ſtrong new bark; produced larger and better-taſted fruit; and that thoſe young ſhoots, which before grew up around the ſtem, and which it was every year neceſſary to deſtroy, were prevented from ſprouting forth, as the covering of flax-ſhows impeded the free acceſs of air at the bottom of the trunk.

In the year 1793, he tranſplanted, from ſeed-beds, into the nurſery, ſeveral fruit-trees; the ground around ſome of which he covered, as above, with flax-ſhows. Notwithſtanding the great heat of the ſummer, none of thoſe trees where the earth was covered with ſhows died or decayed; becauſe the ſhows prevented the earth under them from being dried by the ſun. Of thoſe trees, around which the ground was not covered as before mentioned, the fourth part miſcarried; and thoſe that continued alive were far weaker than the former.

The leaves which fall from trees in autumn may alſo be employed for covering the ground in like manner; but ſtones, or logs of wood, muſt be laid on them, to prevent their being diſperſed by the wind. In graſs-land, a ſmall trench may be made around the roots of the tree, when planted, in order to receive the leaves. If flax-ſhows are uſed, this is not neceſſary; they lie on the ſurface of the ground ſo faſt as to reſiſt the force of the moſt violent ſtorm. The leaves which our author found moſt effectual in promoting the growth and fertility of fruit trees, are thoſe of the walnut-tree. Whether it is, that, on account of their containing a greater abundance of ſaline particles, they communicate manure to the ground, which thereby becomes tender under them; or that they attract nitrous particles from the atmoſphere; or that, by both theſe means, they tend to nouriſh the tree both above and below.

Thoſe who are deſirous of raiſing tender exotic trees from the ſeed, in order to accuſtom them to our climate, may, when they tranſplant them, employ flax-ſhows

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(A) Shows are the refuſe of flax when it is ſcutched or heckled.

with great advantage. This covering will prevent the froſt from making its way to the roots; and rats and mice, on account of the ſharp prickly points of the flax-ſhows, will not be able to ſhelter themſelves under them.

ORCHILLA, a weed uſed in dyeing, which grows in the Canary iſlands, and is monopolized by the government. "It is a minute vegetable (ſays Sir George Staunton), of the lichen kind, growing chiefly upon rocks of a looſe texture, and produces a beautiful violet blue colour."

ORDEAL. See this article in the *Encyclopædia*, at the end of which we have given, from Dr Henry's Hiſtory of England, ſome ſtrong reaſons for ſuſpecting that the ordeal, by fire at leaſt, was a groſs impoſition on the credulity of an ignorant and ſuperſtitious age. This ſuſpicion of impoſture is raiſed to certainty by Profeſſor Beckmann, who, in his Hiſtory of Inventions, gives us the whole proceſs by which the clergy conducted the trial, and brought proofs of innocence or of guilt at their pleaſure. The perſon accuſed was put entirely under their management for three days before the trial, and for as many after it. They covered his hands (when he was to lift red-hot iron) both before and after the proof; ſealed and unſealed the covering. The former was done, as they pretended, to prevent the hands from being prepared any how by art; the latter, that it might be accurately known whether or not they were burnt.

Some artificial preparation was therefore known, elſe no precautions would have been neceſſary. It is highly probable, that during the three firſt days the preventative was applied to thoſe perſons whom they wiſhed to appear innocent; and that the three days after the trial were requiſite to let the hands reſume their natural ſtate. The ſacred ſealing ſecured them from the examination of preſumptuous unbelievers; for to determine whether the hands were burnt, the three laſt days were certainly not wanted. When the ordeal was aboliſhed, and this art rendered uſeleſs, the clergy no longer kept it a ſecret. In the 13th century, an account of it was publiſhed by Albertus Magnus, a Dominican monk (A). If his receipt be genuine, it ſeems to have conſiſted rather in covering the hands with a kind of paſte than in hardening them. The ſap of the *althea* (marſhmallow), the ſlimy ſeeds of the flea-bane, which is ſtill uſed for ſtiffening by the hat-makers and ſilk-weavers, together with the white of an egg, were employed to make the paſte adhere. And by theſe means the hands were as ſafe as if they had been ſecured by gloves.

Hutton's Dictionary.

ORFFYREUS's Wheel, in mechanics, is a machine ſo called from its inventor, which he aſſerted to be a perpetual motion. This machine, according to the account given of it by Graveſande, in his *Oeuvres Philoſophiques*, publiſhed by Allemand, Amſt. 1774, conſiſted externally of a large circular wheel, or rather drum, 12 feet in diameter, and 14 inches deep; being very light, as it was formed of an aſſemblage of deals, having the intervals between them covered with waxed cloth, to conceal the interior parts of it. The two extremities of an iron axis, on which it turned, reſted on two ſupports. On giving a ſlight impulſe to the wheel, in either direction, its motion was gradually accelerated; ſo that, after two or three revolutions, it acquired ſo great a velocity as to make 25 or 26 turns in a minute. This rapid motion it actually preſerved during the ſpace of two months, in a chamber of the Landgrave of Heſſe, the door of which was kept locked, and ſealed with the Landgrave's own ſeal. At the end of that time it was ſtopped, to prevent the wear of the materials. The Profeſſor, who had been an eye-witneſs to theſe circumſtances, examined all the external parts of it, and was convinced that there could not be any communication between it and any neighbouring room. Orffyreus, however, was ſo incenſed, or pretended to be ſo, that he broke the machine in pieces; and wrote on the wall, that it was the impertinent curioſity of Profeſſor Graveſande which made him take this ſtep. The Prince of Heſſe, who had ſeen the interior parts of this wheel, but ſworn to ſecrecy, being aſked by Graveſande, whether, after it had been in motion for ſome time, there was any change obſervable in it, and whether it contained any pieces that indicated fraud or deception? anſwered both queſtions in the negative, and declared, that the machine was of a very ſimple conſtruction.

ORICOU, a new ſpecies of the vulture, diſcovered by Vaillant at Orange river in South Africa. As he thinks it unqueſtionably the moſt beautiful of its genus, and tells, as uſual with him, a wonderful ſtory about it, we have given a figure of this vulture in Plate XLI. Our traveller ſays, that it is more than three feet high, and eight or nine in breadth of wing. Its feathers, the general hue of which is a light brown, are of a particular kind on the breaſt, belly, and ſides, where they are of unequal lengths, pointed, curved like the blade of a ſabre, and briſtle up diſtinct from each other. The feathers being thus ſeparated, would diſcloſe to view the ſkin on the breaſt, if it were not completely covered with a very thick and beautiful white down, which is eaſily ſeen between the ruffled plumage.

A celebrated naturaliſt has ſaid, that "no bird has eye-laſhes or eye-brows, or, at leaſt, hair round the eyes like that in quadrupeds." This aſſertion, advanced as a general law of Nature, is a miſtake. Not only the oricou has this peculiarity, but we know of many other ſpecies in which it exiſts; ſuch as, in general, all the calaos, the ſecretary, and ſeveral other birds of prey. Beſide theſe eye-laſhes, the vulture in queſtion has ſtiff black hairs on its throat. All the head and part of the neck are bare of feathers; and the naked ſkin, which is of a reddiſh colour, is daſhed in certain places with blue, violet, and white. The ear, in its external circumference, is bounded by a prominent ſkin, which forms a ſort

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(A) In his work *De Mirabilibus Mundi*, at the end of his book *De Secretis Mulierum*, Amſtelod. 1702, 12mo, p. 100. Experimentum mirabile quod facit hominem ire in ignem ſine læſione, vel portare ignem vel ferrum ignitum ſine læſione in manu. Recipe ſuccum biſmalvæ, et albumen ovi, et ſemen pſylli et calcem, et pulveriza, et conſice cum illo albumine ovi ſuccum raphani; commiſce; ex hac confectione illineas corpus tuum vel manum, et dimitte ſiccari, et poſtea iterum illineas, et poſt hoc poteris audacter ſuſtinere ignem ſine nocumento.

ſort of rounded conch, that muſt neceſſarily heighten the faculty of hearing in this ſpecies. This kind of conch is prolonged for ſome inches, and deſcends down the neck ; which induced our author to give it the name of *oricou*.

Its ſtrength, he ſays, muſt be very conſiderable, if we may judge from its muſcles and ſinews ; and he is perſuaded, that there is not a ſtronger among the whole order of carnivorous birds, not excepting the famous condor, which ſo many travellers have ſeen, but of which their deſcriptions are ſo different as to render its exiſtence extremely doubtful. But there was no occaſion for this reaſoning, and thoſe inferences, if what he relates as facts deſerve any credit. The oricou which he deſcribes, he firſt perceived perched on the carcaſe of a hippopotamos, eagerly devouring its fleſh. He ſhot at it, and wounded it ſlightly ; upon which, “ though it had already gorged itſelf with a conſiderable quantity of fleſh (for upon opening it, he found in its ſtomach no leſs a quantity than *ſix pounds and a half*), yet its hunger and voracity were ſuch, that it ſtruck its beak into the carcaſe when attempting to take wing, as if deſirous of carrying the whole of it away.

“ On the other hand, the weight of the fleſh it had devoured rendering it the more heavy, it could not eaſily riſe ; ſo that we had time (ſays he) to reach it before it was on the wing, and we endeavoured to knock it on the head with the but-ends of our muſkets. It defended itſelf a long time with great intrepidity. It bit or ſtruck at our weapons with its beak, and its ſtrength was ſtill ſo great, that every ſtroke made a mark on the *barrel of the piece.*”

ORIENT, the eaſt, or the eaſtern point of the horizon.

Orient *Equinoctial*, is uſed for that point of the horizon where the ſun riſes when he is in the equinoctial, or when he enters the ſigns Aries and Libra.

Orient *Aeſtival*, is the point where the ſun riſes in the middle of ſummer, when the days are longeſt.

Orient *Hybernal*, is the point where the ſun riſes in the middle of winter, when the days are ſhorteſt.

OROTAVA, a town in the iſland of Teneriffe, at the bottom of thoſe mountains out of which the Peek riſes, neatly built of ſtone, on an irregular ſurface. The moſt remarkable object near it is a dragon's blood tree, of which the trunk meaſures, at the height of ten feet from the ground, 36 feet in girth. Concerning this tree there is a tradition current in the iſland, that it exiſted, of no inconſiderable dimenſions, when the Spaniards made the conqueſt of Teneriffe, about three centuries ago ; and that it was then, what it ſtill is, a landmark, to diſtinguiſh the boundaries of landed poſſeſſions near it.

Diſtant about three miles on the ſea-coaſt is the puerto, or ſea-port, of Orotava, where is carried on a conſiderable degree of commerce, principally for the exportation of wine. It is chiefly, as at Madeira, in the hands of a few Britiſh commercial houſes, which import, in return, the manufactures of Great Britain. Within a mile is a collection of living plants from Mexico, and other parts of the Spaniſh dominions in America. From hence they are to be tranſplanted into Spain. It is an eſtabliſhment of ſome expence ; and, whatever may be its ſucceſs, it ſhews a laudable attention, on the part of that government, to the promotion of natural knowledge.

OROTCHYS and Bitchys, two tribes of Tartars, who were viſited by La Perouſe in 1787, and of whoſe manners he gives ſuch an account as renders it difficult to ſay whether they have the beſt claim to be called a ſavage or a civilized people. He fell in with a ſmall village of them on the eaſt coaſt of Tartary, in a bay to which he gave the name of *Baie de Caſtrie*, in Lat. 51° 29′ North, and Lon. 139° 39′ Eaſt from Paris.

Their village, their employment, their dreſs, and their apparent ignorance of all religion, beſpoke them ſavages. Their village was compoſed of four cabins, built in a ſolid manner, of the trunks of fir-trees, and covered with bark. A wooden bench compaſſed the apartment round about ; and the hearth was placed in the middle, under an opening large enough to give vent to the ſmoke.

This village was built upon a tongue of low marſhy land, which appeared to be uninhabitable during the winter ; but on the oppoſite ſide of the gulf, on a more elevated ſituation, and expoſed to the ſouth, there was, at the entrance of a wood, another village, conſiſting of eight cabins, much larger and better built than the firſt. Above this, and at a very ſmall diſtance, were three yourts, or ſubterraneous houſes, perfectly ſimilar to thoſe of the Kamtſchadales, deſcribed in the third volume of Captain Cook's laſt voyage ; they were extenſive enough to contain the inhabitants of the eight cabins during the rigour of the cold ſeaſon ; beſides, on ſome of the ſkirts of this village were ſeen ſeveral tombs, which were larger and better built than the houſes ; each of them encloſed three, four, or five biers, of a neat workmanſhip, ornamented with Chineſe ſtuffs, ſome pieces of which were brocade. Bows, arrows, lines, and, in general, the moſt valuable articles of theſe people, were ſuſpended in the interior of theſe monuments, the wooden door of which was cloſed by a bar, ſupported at its extremities by two props.

Their ſole employment ſeemed to be the killing and curing of ſalmon, of which they eat raw, the ſnout, the gills, the ſmall bones, and ſometimes the entire ſkin, which they ſtript off with infinite dexterity. When the ſtript ſalmon were carried to the huts, the women, in the moſt diſguſting manner, devoured the mucilaginous part of them, and ſeemed to think it the moſt exquiſite food. Every cabin was ſurrounded with a drying place for ſalmon, which remain upon poles, expoſed to the heat of the ſun, after having been during three or four days ſmoked round the fire, which is in the middle of their cabin ; the women, who are charged with this operation, take care, as ſoon as the ſmoke has penetrated them, to carry them into the open air, where they acquire the hardneſs of wood.

The bones of the ſalmon ſo cured were ſcattered, and the blood ſpread round the hearth ; greedy dogs, though gentle and familiar enough, licked and devoured the remainder. The naſtineſs and ſtench of this people are diſguſting. There is not perhaps anywhere a race of people more feebly conſtituted, or whoſe features are more different from thoſe forms to which we attach the idea of beauty ; their middle ſtature is below four feet ten inches, their bodies are lank, their voices thin and feeble, like that of children ; they have high cheek bones, ſmall blear eyes, placed diagonally; a large mouth, flat noſe, ſhort chin, almoſt beardleſs, and an olive-coloured ſkin, varniſhed with oil and ſmoke. They ſuffer their hair to grow, and tie it up nearly the ſame as we do; that of the women falls looſe about their ſhoulders, and the portrait which has juſt been drawn agrees equally well with their countenances as thoſe of the men, from whom it would be difficult to diſtinguiſh them, were it not for a ſlight difference in the dreſs, and a bare neck; they are not, however, ſubjected to any labour, which might, like the American Indians, change the elegance of their features, if nature had furniſhed them with this advantage. Their whole cares are limited to the cutting and ſewing their clothes, diſpoſing of their fiſh to be dried, and taking care of their children, to whom they give the breaſt till they are three or four years of age.

With reſpect to dreſs, the men and little boys are clothed with a waiſtcoat of nankeen, or the ſkin of a dog or a fiſh, cut in the ſhape of a waggoner's frock. If it reach below the knee, they wear no drawers; if it do not, they wear ſome in the Chineſe ſtyle, which fall as low as the calf of the leg. All of them have boots of ſeal's ſkin, but they keep them for the winter; and they at all times, and of every age, even at the breaſt, wear a leather girdle, to which are attached a knife in a ſheath, a ſteel to ſtrike a light with, a pipe, and a ſmall bag to contain tobacco. The dreſs of the women is ſomewhat different; they are wrapped up in a large nankeen robe, or ſalmon's ſkin, which they have the art of perfectly tanning, and rendering extremely ſupple. This dreſs reaches as low as the ankle-bone, and is ſometimes bordered with a fringe of ſmall copper ornaments, which make a noiſe ſimilar to that of ſmall bells. Thoſe ſalmon, the ſkins of which ſerve for clothing, are never caught in ſummer, and weigh thirty or forty pounds.

Though they had neither prieſts nor temples, they ſeemed to be believers in ſorcery, and took the motion of the Frenchmens hands, when writing, for ſigns of magic. Thus far they appeared ſavages.

Their ſacred regard of property, their attention to their women, and the delicacy of their politeneſs to ſtrangers, would, on the other hand, do honour to the moſt civilized nation. While Perouſe and his people were in the bay, one of the families took its departure on a voyage of ſome length, and did not return during their ſtay. When he went away, the maſter of the family put ſome planks before the door of his houſe, to prevent the dogs from entering it, and in this ſtate left it full of their effects. "We were ſoon (ſays our author) ſo perfectly convinced of the inviolable fidelity of theſe people, and their almoſt religious reſpect for property, that we left our ſacks full of ſtuffs, beads, iron tools, and, in general, every thing we uſed as articles of barter, in the middle of their cabins, and under no other ſeal of ſecurity than their own probity, without a ſingle inſtance of their abuſing our extreme confidence; and on our departure from this bay, we firmly entertained the opinion, that they did not even ſuſpect the exiſtence of ſuch a crime as theft."

Their attention to their women, ſo uncommon among ſavages, was diſplayed in their exempting them from hard labour; in their never concluding a bargain with the Frenchmen without previouſly conſulting their wives; and in their reſerving the pendent ſilver ear-rings and copper trinkets, which they purchaſed, for their wives and daughters. Of the delicacy of their manners to ſtrangers, we ſhall give the following intereſting inſtance in the words of Perouſe's tranſlator:

Obſerving with what repugnance they received preſents, and how often they refuſed them with obſtinacy, "I imagined (ſays Perouſe) I could perceive, that they were perhaps deſirous of more delicacy in the manner of offering them; and to try if this ſuſpicion were well founded, I ſat down in one of their houſes, and after having drawn towards me two little children, of three or four years old, and made them ſome trifling careſſes, I gave them a piece of roſe-coloured nankeen, which I had brought in my pocket. The moſt lively ſatisfaction was viſibly teſtified in the countenances of the whole family, and I am certain they would have refuſed this preſent, had it been directly offered to themſelves. The huſband went out of his cabin, and ſoon afterwards returning with his moſt beautiful dog, he entreated me to accept of it. I refuſed it, at the ſame time endeavouring to make him underſtand, that it was more uſeful to him than to me: but he inſiſted; and perceiving that it was without ſucceſs, he cauſed the two children, who had received the nankeen, to approach, and placing their little hands on the back of the dog, he gave me to underſtand, that I ought not to refuſe his children.

"The delicacy of ſuch manners cannot exiſt but among a very poliſhed people. It ſeems to me, that the civilization of a nation, which has neither flocks nor huſbandry, cannot go beyond it. It is neceſſary to obſerve, that dogs are their moſt valuable property; they yoke them to ſmall and very light ſledges, extremely well made, and exactly ſimilar to thoſe of the Kamtſchadales. Theſe dogs, of the ſpecies of wolf dogs, and very ſtrong, though of a middle ſize, are extremely docile, and very gentle, and ſeem to have imbibed the character of their maſters."

ORTHODROMICS, in navigation, is great-circle ſailing, or the art of ſailing in the arch of a great circle, which is the ſhorteſt courſe: For the arch of a great circle is *orthodromia*, or the ſhorteſt diſtance between two points or places.

ORYCTEROPUS, the name given by M. Geoffroy, profeſſor of zoology in the French muſeum of natural hiſtory, to the animal called by other zoologiſts *Myrmecophaga Capenſis*. (See MYRMECOPHAGA, *Encycl.*) He conſiders it as a diſtinct genus, and ſeems indeed to have proved, by a compariſon of the organs of the orycteropus with thoſe of the *tatous daſypus* of Linnæus, and of the *myrmecophagi*, that this genus is intermediate, by its forms and habits, between thoſe two families. It approaches to the *tatous* in its organs of maſtication, and the form of the toes and nails, and in having a ſhort and ſingle cæcum, whilſt that of the myrmecophagi is double, as in birds, by the reuniting of the bones of the os pubis, which are not articulated together in the myrmecophagi. The orycteropus, however, bears a relation to the laſt, ſince it has, like them, a very ſmall mouth, whence its tongue, covered with hair, may be protruded to a conſiderable length. Finally, the habits of the orycteropus reſemble thoſe of the animals to which it approaches the moſt; it does not climb trees, but lives under the earth like the tatous;

tous; it feeds like them on roots, but alſo it hunts after anthills, like the myrmecophagi. Its ſnout terminates in a blunt callous; a character which is peculiar to it. It may be diſtinguiſhed in the works of naturaliſts by the following deſcription:

Orycteropus. Molar teeth (ſix) with flat vertices; the body covered with hair.

The orycteropus, as appears from the preceding, connects the tatous with the myrmecophagi and with the *pangolin manis* of Linnæus. The large foſſile ſpecies found in Paraguay, for which Citizen Cuvier has eſtabliſhed a new genus, under the name of *megaterium*, is intermediate between the ſloth and the myrmecophagus; and, laſtly, the aſtoniſhing animal of New Holland, covered with briſtles like the porcupine, ſupported by very ſhort legs, and of very ſingular conformation, and with a head round at the occiput, terminating in a ſnout, without teeth, very ſlender, long, and cylindrical, and deſcribed by Mr George Shaw under the name of myrmecophaga aculeata, appears to have very ſtriking relations to the pangolin and the orycteropus: from hence it follows, that in conſequence of theſe important acquiſitions, we ought for the future to count, in the number of our natural orders, that of the *edentated*, or *edented*, conſiſting of the following genera: *Daſipus*, *orycteropus myrmecophaga*, and *aculeata*, *manis*, *myrmecophaga*, *megaterium* et *bradypus*.

OSCILLATION, in mechanics, vibration, or the reciprocal aſcent and deſcent of a pendulum.

Axis of Oscillation, is a line parallel to the horizon, ſuppoſed to paſs through the centre or fixed point about which the pendulum oſcillates, and perpendicular to the plane in which the oſcillation is made.

Centre of Oscillation, in a ſuſpended body, is a certain point in it, ſuch that the oſcillations of the body will be made in the ſame time as if that point alone were ſuſpended at that diſtance from the point of ſuſpenſion. Or it is the point into which, if the whole weight of the body be collected, the ſeveral oſcillations will be performed in the ſame time as before: the oſcillations being made only by the force of gravity of the oſcillating body.

OSCULATION, in geometry, denotes the contact between any curve and its oſculatory circle; that is, the circle of the ſame curvature with the given curve, at the point of contact or of oſculation. See Involution. in this *Suppl.*

Osculation alſo means the point of concourſe of two branches of a curve which touch each other. For example, if the equation of a curve be $y = \sqrt{x} + \sqrt[4]{x^3}$, it is eaſy to ſee that the curve has two branches touching one another at the point where $x = 0$, becauſe the roots have each the ſigns + and —.

OUADELIM and Labdesseba, two tribes of Arabs inhabiting the *Sahara* or Great Deſart of Africa, of whom almoſt nothing was known to Europeans till the publication of Briſſon's narrative of his ſhipwreck and captivity among the latter tribe. He deſcribes the Ouadelim and Labdeſſeba as the moſt formidable of all the interior tribes of Arabs, and as often extending their ravages to the very gates of Morocco. "Their hordes (he ſays) are frequently intermingled with thoſe of the Rouſege, Rathidium, Chelus, Tucanois, and Ouadelim tribes, as they have no diſtinct boundaries, and change their habitations as the deſart affords paſturage and water. They are tall, handſome, ſtout, and vigorous men. Their hair is briſtled, and their nails, which they often uſe in battle, as long as claws; large hanging ears and a long beard give them a ſtern ferocious air. The Ouadelim in particular are fierce, arrogant, and warlike, but ſoon diſpirited by obſtinate reſiſtance, eſpecially when they have not a decided ſuperiority in numbers. In their hordes they lodge by families, in tents which are covered with a thick cloth of camels hair, which the women ſpin and weave upon a loom ſo ſmall, that they work ſitting on the ground. The furniture of their tents conſiſt of two large ſacks of leather, in which they keep old clothes and pieces of old iron, three or four goat ſkins for holding milk and water, two large ſtones for grinding their barley, a ſmaller one for driving the pins of their tents, an ozier matting which ſerves for a bed, a thick carpet for a covering, a ſmall kettle, and ſome wooden diſhes, with pack-ſaddles for their camels. The perſon who, beſides theſe articles, poſſeſſes a few horſes, camels, ſheep, and goats, is reckoned wealthy, as there are many Arabs who only poſſeſs ſheep and goats. Except ſore eyes and the cholic, they are ſubject to few endemic diſeaſes. The firſt diſorder is cauſed by the reflection of light from the burning ſands of the deſart; the other proceeds from the verdigreaſe which contaminates all their victuals. Their kettles are not tinned, and never waſhed, ſo that they are quite cruſted over with verdigreaſe, the virulence of which is probably diminiſhed by the quantity of milk they uſe. When they reſide long in one place, they ſometimes plough the ſpots which are moiſtened by the rain, and ſprinkle them with ſeed in a careleſs manner. Plentiful crops are often thus produced; but inſtead of waiting till the grain attains maturity, they cut it down, and dry it over hot cinders. Treachery and perfidy are the innate vices of the Arabs; aſſaſſinations are frequent; no man truſts the promiſe of another; no man makes a written agreement, as the poignard cancels all bonds and obligations. The men often relate their exploits to each other; the embelliſhing of a ſtory is ſucceeded by a charge of falſehood, and the poignard ſolves every difficulty. The ancient rites of hoſpitality, however, are practiſed among theſe tribes in their utmoſt extent. The Arab, who in the field is a rapacious plunderer, becomes liberal and generous as ſoon as he enters his tent. War is only a ſpecies of rapine, and the victory is decided at the firſt ſhock. The Arab is devoid of ſanguinary courage; he attacks only to plunder, and never thinks that booty is to be put in competition with his life. When the battle is ended, each party makes graves for the ſlain, and encloſe the tombs with mounds of ſtones. The ages of the warriors are denoted by the ſpace of ground which the grave occupies, and the funeral proceſſion is cloſed by the howls of the females.

"The women never aſſume the name of their huſbands, and never eat with them at meals. They are faithful to their huſbands, and cannot be divorced except by the decree of the ſeniors of the horde. The Arabs diſplay their opulence by the ornaments of their women, whoſe ears, arms, and legs, are generally adorned with rings of gold and ſilver. An Arab beauty muſt have long teeth ſhooting out of her mouth, a body extremely thick, and limbs of the longeſt ſize. At the birth of a ſon, every woman, to teſtify her joy, black-

Ouadelim. ens her face for 40 days. At the birth of a daughter, ſhe only daubs the half of her face during the ſpace of 20 days. A mother treats her ſon with the ſame reſpect as her huſband, almoſt as ſoon as he is able to walk; ſhe prepares his food, ſerves him, and eats when he has finiſhed his repaſt. In the education of their young men, the moſt important acquiſitions are, dexterity in the uſe of the poignard, ſkill in embowelling their enemies with their long nails, and a plauſible air in uttering a falſehood. More rude and ferocious than the tribes whoſe territories lie upon the ſhore of the ſea, the Labdeſſeba and Ouadelim Arabs are alſo more confined and illiberal in their ideas, not only believing that they are the firſt nation in the world, but fancying that the ſun riſes only for them. Briſſon relates, that ſome of them expreſſed this idea in unequivocal terms. ‘Behold (ſaid they) that luminary, which is unknown in thy country. During the night, thou art not enlightened, as we are, by that heavenly body, which regulates our days and our faſts. His children (the ſtars) point out to us the hours of prayer. You have neither trees nor camels, ſheep, goats, nor dogs. Are your women ſimilar to ours?’ ‘How long didſt thou remain in the womb of thy mother (ſaid another)?’ ‘As long (replied Briſſon) as thou in that of thine.’ ‘Indeed (ſaid a third, counting the fingers and toes of the Frenchman) he is made like us; he differs only in his colour and language.’ ‘Do you ſow barley in your houſes?’ ſaid the Arabs, alluding to the ſhips of the Europeans. ‘No (ſaid Briſſon), we ſow our fields almoſt in the ſame ſeaſon as you.’ ‘How! (cried ſeveral) do you inhabit the earth? we believed that you were born and lived upon the ſea.’ These Arabs, according to the Turkiſh proverb, believe that all the world is like their father's houſe: unacquainted with the manners of other nations, and unaccuſtomed to reflect upon the cauſes of national character, every variation from their own cuſtoms appears not only ridiculous, but monſtrous; every difference of opinion not only abſurd, but criminal. This ignorance of the Arabs, conjoined with their local and religious prejudices, enables us to account for the inſulting treatment which Briſſon and his companions received, without having recourſe to inherent depravity of nature.” That treatment was indeed ſhocking.

Briſſon had ſurrendered himſelf, on his ſhipwreck, to Sidi Mahomet, a *Talbe* or prieſt of the tribe of Labdeſſeba. During the abſence of the prieſt, the Labdeſſeba, who guarded the captives, were attacked and maltreated by a party of the Ouadelims, and during the buſtle which enſued, Briſſon had almoſt loſt his life. Inſtead of compaſſionating his forlorn ſituation, the women threw ſand into his eyes, as they ſaid, to dry his eye-lids. The Arabs, into whoſe hands he had fallen, had only come down to the ſea-coaſt to gather wild grain, three days before the ſhipwreck; and to preſerve their booty, they immediately retreated to the interior part of the deſart. A guide preceded the horde, to place at intervals ſmall pyramids of ſtone, to direct their courſe, at a diſtance from every hoſtile tribe. After paſſing ſome very high mountains, wholly covered with ſmall greyiſh pebbles as ſharp as flints, they deſcended into a ſandy plain overſpread with thorns and thiſtles. When Briſſon was unable to walk, on account of the bleeding of his feet, he was mounted on a camel; the briſtly hair and hard trot of which ſoon excoriated him ſo much, that the blood run copiouſly down its flanks. By throwing heated ſtones into a wooden veſſel, filled with barley meal, diluted with water procured on the ſea-ſhore, preſerved in a goat's ſkin, and mixed with pitch to prevent putrefaction, the Arabs prepared a kind of ſoup, which they kneaded with their hands, and ate unchewed. They roaſted a goat in heated ſand, ate its fat raw, and, after having devoured the fleſh, gnawed the bones, and ſcraped them with their nails, threw them to Briſſon and his companions, deſiring them to eat quickly, and load the camels, that the journey might not be impeded. Proceeding eaſtward, they croſſed a vaſt plain, covered with ſmall ſtones white as ſnow, round and flat as a lentil, where not a ſingle plant was produced. The earth beneath their feet reſounded dull and hollow, and the ſmall ſtones pricked them like ſparks of fire. The reflection of the rays of the ſun from the ſand was ſcorching; the atmoſphere was loaded with a red vapour, and the country appeared as if filled with flaming volcanoes. Neither birds nor inſects could be ſeen in the air. The profound ſilence was frightful. If a gentle breeze ever aroſe, it produced extreme languor, chopping of the lips, burning heat of the ſkin, with ſmall ſmarting pimples. This plain was even ſhunned by wild beaſts. After traverſing this plain, they entered another, where the wind had thrown up in furrows the ſand, which was of a reddiſh colour. On the tops of the furrows grew a few ſweet-ſcented plants, which were devoured by the camels. On quitting this ſandy plain, they entered a valley ſurrounded by mountains, where the ſoil was white and ſlimy, and where they found water of a noxious ſmell, covered with green moſs, and ſoon after diſcovered a horde of the friendly tribe Rouſſye.

After another journey of ſixteen days, they arrived at the tents of the Labdeſſeba horde, to which Sidi Mahomet belonged. The tents pitched among thick buſhy trees, and the numerous flocks feeding along the ſides of the hills, preſented at a diſtance an aſpect of happineſs and paſtoral ſimplicity. On approaching near, the trees of beautiful green foliage proved to be only old gummy ſtumps, almoſt void of branches, ſo encircled with thorns that their ſhade was inacceſſible. The women approached, with loud cries and the moſt fawning ſervility, to welcome their tyrants, to throw ſtones at the Chriſtians, and ſpit in their faces, while the children imitated the example of their mothers. Briſſon, who endeavoured to ingratiate himſelf with his maſter's favourite, not only failed in this, but incurred her implacable reſentment, through his irritability, which to the Arab women ſeemed extremely to reſemble petulance. During his reſidence with Sidi Mahomet, the hardſhips he endured were almoſt incredible. With the exceſſive heat, the milk of the ſheep, goats, and camels, diminiſhed, and then the dogs fared better than the Chriſtians, who were forced to ſubſiſt on wild herbs and raw ſnails. When the rains fell, and the leaſt preſſure made the water to ſpring up through the ſandy ſoil, the Chriſtians ſlept behind a buſh, unſheltered, on the bare ground. Briſſon and his maſter ſometimes reaſoned about religion; when the latter always anſwered the harangues of the former by declaring, that he preferred a bowl of churned milk to ſuch

Oxyglycus, Oxy-Muriatic Acid

abſurdities. Several of his companions periſhed, and were left by the Arabs to be devoured by the ravens, while in the ſtruggles of death. One of them was ſuppoſed to be murdered by his maſter for milking his camels clandeſtinely. An application made by Briſſon to the conſul at Mogador, by a letter entruſted to a Jewiſh merchant, was fruſtrated through the negligence of the vice-conſul; and the Labdeſſeba Arabs thought the journey too dangerous to be encountered for the ranſom of their ſlaves. He was, however, at laſt relieved, through the humanity of his maſter's brother-in-law, who carried him to Morocco, where his ranſom was paid by the Emperor, and whence he returned to France. For a fuller account of theſe two ſavage tribes, ſee *Saugnier's and Briſſon's Narratives*; or a very pleaſing *Hiſtorical and Philoſophical Sketch of the Diſcoveries, &c. of the Europeans in Northern and Weſtern Africa*, publiſhed 1799 by *Symington* Edinburgh, and *Vernor* and *Hood* London.

OXYGLYCUS CERASUS, the name given by the editor of Dalzel's Hiſtory of Dahomy to a very ſingular fruit produced in that country, as well as in ſome other parts of Africa. It reſembles a ſmall olive in every reſpect but the colour; being of a duſky reddiſh hue, changing at the end next the ſtalk to a faint yellow. The pulp is firm, and almoſt inſipid; the ſtone is hard like that of the olive. After having chewed one or more of ſuch berries, and ſpit out or ſwallowed the pulp at pleaſure, a glaſs of vinegar will taſte, to the perſon trying the experiment, like ſweet wine; a lime will ſeem to have the flavour of a very ripe China orange; and the ſame change is produced on other acids, the ordinary effects of which upon the palate is deſtroyed in a very unaccountable manner, without efferveſcence or any ſenſible motion. Indeed, the effect is very different from neutralization, ariſing from the mixture of acid and alkali; ſuch combination producing a neutral ſaline liquor, whilſt this miraculous berry ſeems to convert acids to ſweets. Food or drink, not containing any acid, ſuffer no change by the previous uſe of this fruit; its effect upon acids continues, even after a meal, though in a much ſmaller degree. The natives uſe it to render palatable a kind of gruel called *guddoe*, which is made of bread after it becomes too ſtale for any other purpoſe. They deſcribe it as the fruit of a large tree.

Plants ſix or ſeven inches high were raiſed from this fruit by Mr Dalzel, who tried to carry them from Angola to the botanic garden at St Vincent's; but they died on the paſſage. He preſerved the berries in ſpirits, in ſyrup, and in a dry form; but they loſt their ſingular quality in all thoſe preparations. The plant is an evergreen, and the leaves in this infant ſtate are like thoſe of the olive.

OXY-MURIATIC ACID (See CHEMISTRY-*Index* in this *Suppl.*), is the principal agent in the new proceſs of bleaching (ſee BLEACHING, *Suppl.*); but, till very lately, at leaſt, if not even at preſent, the bleachers were in the practice of adding ſome alkali to the acid, notwithſtanding the ſtrong objections which M. Bertholet made to that addition, and notwithſtanding the proofs urged by Mr Rupp, that it increaſes the expence of bleaching about 40 *per cent.* The chief reaſon for perſiſting in a practice to which ſuch objections were urged was, that the addition of the alkali deprives the liquor of its ſuffocating effects without deſtroying its bleaching powers. Mr Rupp, however, has contrived the following apparatus, in which may be ſafely uſed the pure oxy-muriatic acid ſimply diſſolved in water, which is at once its cheapeſt and beſt vehicle.

Oxy-Muriatic Acid.

Figure 1. (Plate XLI.) is a ſection of the apparatus. It conſiſts of an oblong deal ciſtern ABCD, made water-tight. A rib EE of aſh or beech wood is firmly fixed to the middle of the bottom CD, being mortiſed into the ends of the ciſtern. This rib is provided with holes at FF, in which two perpendicular axes are to turn. The lid AB has a rim GG, which ſinks and fits into the ciſtern. Two tubes HH are fixed into the lid, their centres being perpendicularly over the centres of the ſockets FF when the lid is upon the ciſtern. At I, is a tube by which the liquor is introduced into the apparatus. As it is neceſſary that the ſpace within the rim GG be air-tight, its joints to the lid, and the joints of the tubes, muſt be very cloſe; and, if neceſſary, ſecured with pitch. Two perpendicular axes KL, made of aſh or beech wood, paſs thro' the tubes HH, and reſt in the ſockets FF. A piece of ſtrong canvas M is ſewed very tight round the axis K, one end of it projecting from the axis. The other axis is provided with a ſimilar piece of canvas. N are pieces of cloth rolled upon the axis L. Two plain pulleys OO are fixed to the axes, in order to prevent the cloth from ſlipping down. The ſhafts are turned by a moveable handle P. Q is a moveable pulley, round which paſſes the cord R. This cord, which is faſtened on the oppoſite ſide of the lid (ſee fig. 2.), and paſſes over the ſmall pulley S, produces friction by means of the weight T. By the ſpigot and fauſſet V, the liquor is let off when exhauſted.

The dimenſions of this apparatus are calculated for the purpoſe of bleaching twelve or fifteen pieces of $\frac{4}{4}$ calicoes, or any other ſtuffs of equal breadth and ſubſtance. When the goods are ready for bleaching, the axis L is placed on a frame in an horizontal poſition, and one of the pieces N being faſtened to the canvas M by means of wooden ſkewers, in the manner repreſented in fig. 1. it is rolled upon the axis by turning it with the handle P. This operation muſt be performed by two perſons; the one turning the axis and the other directing the piece, which muſt be rolled on very tight and very even. When the firſt piece is on the axis, the next piece is faſtened to the end of it by ſkewers, and wound on in the ſame manner as the firſt. The ſame method is purſued till all the pieces are wound upon the axis. The end of the laſt piece is then faſtened to the canvas of the axis K. Both axes are afterwards placed into the ciſtern, with their ends in the ſockets FF, and the lid is put on the ciſtern by paſſing the axes through the tubes HH. The handle P is put upon the empty axis, and the pulley Q upon the axis on which the cloth is rolled, and the cord R, with the weight T, is put round it and over the pulley S. The uſe of the friction, produced by this weight, is to make the cloth wind tight upon the other axis. But as the effect of the weight will increaſe as one cylinder increaſes and the other leſſens, Mr Rupp recommends that three or four weights be ſuſpended on the cord, which may be taken off gradually as the perſon who works the machine may find it convenient. As the weights hang in open hooks, which are faſtened to the cord, it will be little or no trouble to put them on and to remove them.

Things being thus diſpoſed, the bleaching liquor is to be transferred from the veſſels in which it has been prepared into the apparatus, by a moveable tube paſſing through the tube I, and deſcending to the bottom of the ciſtern. This tube being connected with the veſſels, by means of leaden or wooden pipes provided with cocks, hardly any vapours will eſcape in the transfer. When the apparatus is filled up to the line *a*, the moveable tube is to be withdrawn, and the tube I cloſed. As the liquor riſes above the edge of the rim G, and above the tubes HH, it is evident that no evaporation can take place, except where the rim does not apply cloſely to the ſides of the box; which will, however, form a very trifling ſurface if the carpenter's work be decently done. The cloth is now to be wound from the axis L upon the axis K, by turning this; and when this is accompliſhed, the handle P and pulley Q are to be changed, and the cloth is to be wound back upon the axis L. This operation is, of courſe, to be repeated as often as neceſſary. It is plain, that by this proceſs of winding the cloth from one axis upon the other, every part of it is expoſed, in the moſt complete manner, to the action of the liquor in which it is immerſed. It will be neceſſary to turn, at firſt, very briſkly, not only becauſe the liquor is then the ſtrongeſt, but alſo becauſe it requires a number of revolutions, when the axis is bare, to move a certain length of cloth in a given time, though this may be performed by a ſingle revolution when the axis is filled. Experience muſt teach how long the goods are to be worked; nor can any rule be given reſpecting the quantity and ſtrength of the liquor, in order to bleach a certain number of pieces. An intelligent workman will ſoon attain a ſufficient knowledge of theſe points. It is hardly neceſſary to obſerve, that, if the liquor ſhould retain any ſtrength after a ſet of pieces are bleached with it, it may again be employed for another ſet.

With a few alterations, this apparatus might be made applicable to the bleaching of yarn. If, for inſtance, the pulley O were removed from the end of the axis K, and fixed immediately under the tube H;—if it were perforated in all directions, and tapes or ſtrings paſſed through the holes, ſkains of yarn might be tied to theſe tapes underneath the pulley, ſo as to hang down towards the bottom of the box. The apparatus being afterwards filled with bleaching liquor, and the axis turned, the motion would cauſe every thread to be acted upon by the liquor. Several axes might thus be turned in the ſame box, and being connected with each other by pulleys, they might all be worked by one perſon at the ſame time; and as all would turn the ſame way and with the ſame ſpeed, the ſkains could not poſſibly entangle each other.

P.

ENCAUSTIC PAINTING is an art of very high antiquity, which, after being loſt for many ages, was reſtored, as is commonly believed, by the celebrated Count Caylus, whoſe method was greatly improved, firſt by Mr Joſiah Colebrooke, and afterwards by Miſs Greenland, who brought the rudiments of her knowledge from Italy (See ENCAUSTIC, *Encycl.*). In that country encauſtic painting had employed the attention of various artiſts and men of learning, ſuch as Requeno, Lorgna, and Aſtori, &c.; but the beſt account of it that has fallen under our notice, is in that valuable miſcellany called the *Philoſophical Magazine*, taken from a work of Giov. Fabbroni, publiſhed at Rome in the year 1797.

According to this author, "the knowledge and uſe of encauſtic painting is certainly older than the time of the Greeks and the Romans, to whom the learned Requeno ſeems to aſſign the excluſive poſſeſſion of this art; becauſe the Egyptians, who, with the Etruſcans, were the parents of the greater part of the inventions known among mankind, and from whom the Greeks learned ſo much, were acquainted with and employed encauſtic painting in the ancient ages of their greatneſs and ſplendour, as is proved by the valuable fragments of the bandages and coverings of ſome mummies which he had examined. No oil-painting (he ſays), of only two or three hundred years old, exhibits a white paint which has kept ſo well as that ſeen on theſe fragments; and this circumſtance ſufficiently proves the ſuperiority of the encauſtic method over the common oil-painting, which, notwithſtanding the general opinion, cannot, he thinks, have been unknown to the ancients.

"It is impoſſible (ſays he) that in Egypt and Phœnicia, where ſo much uſe was made of flax, the oil procured in abundance from that plant ſhould have been unknown. Thoſe who have kept oil, or who have ſpilt any of it, whether nut or lintſeed oil, muſt have remarked that it poſſeſſes the property of ſoon drying by the effects of the atmoſphere; and therefore it may be eaſily believed that mankind muſt ſoon have conceived the idea of employing it, particularly for ſhips, which, as Herodotus ſays, were painted with red ochre in the earlieſt periods, and adorned with figures and ornaments. The uſe of oil afforded painting a much ſimpler and eaſier method than that of wax; it muſt therefore have been firſt adopted, and the tranſition from oil to wax muſt be conſidered as a ſtep towards bringing the art to perfection; becauſe encauſtic painting is not expoſed to the irremediable inconveniences that ariſe in oil-painting, the value of which we extolled through ignorance, and praiſed as a new invention.

"Oil in general, and in particular drying oil which the painters uſe, has naturally a ſtrong inclination to combine itſelf with the vital air or oxygen of the atmoſphere, and by imbibing oxygen it becomes dry, and aſſumes the character of reſin; but the colour then becomes darker, as is the caſe with tranſparent turpentine, which gradually becomes a black pitch.

“ According to the new and more accurate method of decompoſing bodies, oil conſiſts principally of hydrogen and carbon. By coming into contact with the atmoſphere, and abſorbing its oxygen and light, it undergoes a ſlow and imperceptible combuſtion, which is not eſſentially different from the ſpeedy and violent one which it would undergo in the common mode of burning. It firſt paſſes, by imbibing oxygen, into the ſtate of a more or leſs dark reſin; loſes gradually its eſſential hydrogen, which makes a new combination, and afterwards the oxygen itſelf which has attracted the carbon; and at length leaves behind a thin layer of actual carbon, which in the end becomes black in the courſe of time, and conſiderably obſcures the oil-painting. By a continuance of the before-mentioned ſlow combuſtion, the carbon itſelf, as it were, burns alſo: if it be ſtrongly acted upon by the light, it attracts the oxygen of the atmoſphere, and again brings forward the carbonic acid or fixed air, which gradually flies off. By this, which I may call the ſecond degree of combuſtion, the painting muſt become duſty and friable, like crayon *painting*.

“ Hence it appears (ſays our author) that one can hope only for a tranſient or deceitful effect from the refreſhing of oil-paintings with oil; becauſe the harmony of the tones, which the painter eſtabliſhes as ſuited for the moment, does not proceed with equal ſteps, and cannot preſerve itſelf in the like meaſure for the courſe of a few years, as each tint, as they ſay, ought to increaſe, or, to ſpeak more properly, to burn in proportion to its antiquity. It thence follows, that mere waſhing may be prejudicial to an old painting; and that the method of refreſhing paintings, as it is called, by daubing over the ſurface, from time to time, with new drying oil, is highly prejudicial and ill calculated for the intended purpoſe, ſince the oil when it becomes dry contracts in its whole ſurface, carries with it the paint under it, and occaſions cracks in the painting. New oil of this kind gives occaſion to mineral paints to be reſtored; but covers the picture with a new coat of reſin, and then of carbon, which ariſes from the gradual combuſtion, and always cauſes more blackneſs, and the decay of the painting which one wiſhes to preſerve.

“ Wax, on the other hand, undergoes a change which is very different from that of drying oil. The wax, inſtead of becoming black by the contact of the atmoſphere, increaſes in whiteneſs, and, according to its natural quality, is not decompoſed in the air, and it does not ſtrongly attract the oxygen of the calces or metallic aſhes which are commonly uſed in painting. Moreover, the ſo called earths, which are in themſelves white, and are never variable either by the preſence or abſence of oxygen, cannot be employed in oil-painting, becauſe that fluid makes them almoſt tranſparent, and cauſes them to remain as it were without body, and not to produce the wiſhed-for effect. That beautiful white, which may be obſerved on the before-mentioned Egyptian encauſtic, is nothing elſe than a ſimple earth, and according to our author's chemical experiments, a chalk which is alſo unalterable.”

That the ancients were once acquainted with the uſe of oil-painting, and neglected it on account of the great ſuperiority of the encauſtic method, our author thinks farther evident from the different accounts which we have of the ancient paintings. “ Thus Petronius praiſes the freſh appearance which the valuable works of Zeuxis and Apelles had, even in his time; but Cicero, on the other hand, ſpeaks of the paintings of the ancients having ſuffered from blackneſs. The former ſpeaks of wax-painting, and the latter certainly alludes to paintings in oil. It is well known that paintings with wet chalks or water colours do not become black by age, and that this is the caſe alſo with encauſtic. Of this any one may be convinced, not only by the expreſſions of the above quoted authors, but by one's own eyes on ſurveying the Egyptian fragment alluded to. Galland proves, on various grounds, that a painting was made with oil ſo early as the reign of Marcus Aurelius; and if no ſpecimens of that period have reached us, this is perhaps to be aſcribed to the frail and periſhable nature of this ſpecies of painting.”

Sign. Fabbroni, after ſome farther obſervations, calculated to prove that metallic oxyds or calces could not have been employed as pigments on ſuch mummies as ſtill retain their colours freſh, proceeds thus: “ Thoſe who are acquainted with the accuracy and certainty of the method not long ſince introduced into chemical operations, will be convinced, that in 24 grains of the encauſtic painting, which I ventured to detach from the above-mentioned Egyptian fragment, in order to ſubject it to examination, the mixture of an hundredth part of a foreign ſubſtance would have been diſcovered with the greateſt certainty; that the reſin of Requeno muſt undoubtedly have been perceptible to me, and that the alkali of Bachelier and Lorgna could not have eſcaped the counteracting medium. But in this Egyptian encauſtic I found nothing except very pure wax, though I varied my analyſis in every known method. I muſt therefore conclude, that modern learned writers, at leaſt in reſpect to this Egyptian mode of painting, were as far from the truth as the accounts of ancient authors appear to me preciſe and ſatisfactory; and that the encauſtum with which formerly the fore part of ſhips and the walls of houſes and temples were painted, was ſomething different from ſoap or reſinous crayons.

“ I am well aware that it will be aſked, In what manner can wax at preſent be rendered ſufficiently liquid for the ſtrokes of the pencil, if it be not converted into powder or ſoap? This queſtion, in my opinion, can be fully anſwered from the words of an ancient author, and, in the next place, by experience.

“ Vitruvius in particular, book vii. chap. ix. expreſſes himſelf in the following clear manner:

‘ Thoſe (ſays he) who wiſh to retain cinnabar on walls, cover it, when it has been well laid on and dried, with Punic wax diluted in a little oil (let this be well remarked); and after they have ſpread out the wax with a hair bruſh, they heat the wall by means of a brazier filled with burning coals (hence it is called encauſtic painting), and then make it ſmooth and level by rubbing it with wax tapers and clean cloths, as is done when marble ſtatues are covered with wax. The effect of this wax cruſt is, that the colour is not deſtroyed by the light of the ſun or the moon (A).’

(A) The reader will find the original of this paſſage, with a tranſlation ſomewhat different, in the article ENCAUSTIC, *Encycl.*

“ It here appears, that the Romans, who copied the Grecian proceſs, which the latter borrowed from the Egyptians, mixed the wax with an oil to make it pliable under the bruſh ; but no maſtic, alkali, or honey, as has been ingeniouſly imagined, and which ſome have thought might be employed with ſucceſs. The difficulty now will be confined to point out in what manner this oil was employed. It does not appear that they uſed thoſe fat oils which are commonly called drying oils; becauſe they could have employed theſe as we do, without the addition of wax, which, in ſuch a caſe, would have been entirely ſuperfluous. Fat oils which do not dry would not have been proper for that purpoſe, as they would have kept the wax continually in the ſtate of a ſoft pomade or ſalve. Beſides, my experiments (continues the author) would without doubt have ſhewn me the exiſtence of any oily matter.

“ With regard to eſſential or volatile oils, a knowledge of them is not allowed to the ancients, as the invention of diſtilling is not older than the eighth or ninth century, and therefore falls in with the period of Geber or Avicenna.” Yet it is certain, that, in order to uſe wax in their encauſtic painting, they muſt have combined it with an ethereal volatile oil, of which no traces ſhould afterwards remain ; becauſe this was neceſſary for the ſolidity of the work, and becauſe no oil was found in the fragment that was examined. But naphtha is ſuch an oil, much lighter (ſays our author) than ether of vitriol itſelf. It is exceedingly volatile, and evaporates without leaving a trace of it behind. On this account it is uſed when ſignatures and manuſcripts are to be copied ; becauſe the paper, which is moiſtened by it, and ſo rendered tranſparent, quickly becomes white and opaque as before by the complete evaporation of the naphtha. That the Aſſyrians, Chaldeans, and Perſians, were well acquainted with the properties of naphtha is known to every ſcholar ; and hence our author thinks it highly probable that it was uſed by thoſe nations to render wax fit for painting. “ It appears to me (ſays he) that the Greeks, as was the caſe with many other things, learned encauſtic from the Egyptians, who probably derived it from the Aſſyrians or Chaldeans ; and if ſo, we have diſcovered the real mixture uſed for ancient encauſtic painting.”

To put the matter, however, beyond a doubt, Sign. Fabbroni prepared, for an eminent Saxon painter, a ſolution of Venetian wax in highly purified naphtha, deſiring him to mix up with it the colours neceſſary for a painting. The artiſt complied ; and both he and our author were aſtoniſhed, as well as all their friends, at the high tone which the colours aſſumed, and the agreeable luſtre which the painting afterwards acquired when it had been rubbed over with a ſoft cloth. A ſimilar ſolution of wax was made for another artiſt, in which the ſpirit of turpentine was uſed inſtead of naphtha with equal ſucceſs. Our author therefore concludes, we think with reaſon, that if he has not diſcovered the real compoſition employed by the ancients in their encauſtic paintings, he has at leaſt approached much nearer to that diſcovery than any of his predeceſſors who have employed their learned labours in the ſame field of inveſtigation.

PAINTINGS, or PICTURES, are often done upon objects from which, when they are valuable, it would be deſirable to transfer them. Thus, a connoiſſeur in painting might naturally wiſh to transfer an old and valuable picture from the ceiling or walls of his room to ſtretched canvas ; and ſuch a man would conſider himſelf as deeply indebted to the artiſt who ſhould perform ſo arduous a taſk. This taſk has actually been performed by Mr *Robert Salmon* of Woburn, Bedfordſhire, who was honoured by the *Society for the Encouragement of Arts, &c.* with the greater ſilver pallet, for communicating the method by which he accompliſhed it.

“ The firſt thing (ſays Mr Salmon) to be attended to with reſpect to paintings, either on plaſtered walls or ceilings, or on boards, is, that the place in which they are be ſecure from wet or damp. If the paintings are on old walls in large buildings, or other places where this cannot be attained by art, then the ſummer ſeaſon ſhould be taken for the purpoſe, as the picture will rarely eſcape damage, if wet or damp gets at it while under the proceſs. At the ſame time, care ſhould be taken that the room, or other place, be not overheated ; as that would produce equally bad effects.

“ Theſe precautions being taken, the next thing is to examine the ſurface of the painting. If there are any holes in the ſame, they muſt be carefully filled up with a paſte or putty, made of glue and whiting : this, if the holes are large, ſhould be twice or thrice done, ſo as entirely to fill them up, and leave the ſurface even and ſmooth ; but if there are any bruiſed places, with paint ſtill remaining on the ſurface of the bruiſed parts, then this ſtopping muſt not be applied, but the ſecuring-canvas, hereafter deſcribed, muſt be preſſed down into theſe places. In the places that are ſtopped, there will of courſe appear blemiſhes when the picture is transferred ; but the proceſs is rendered much more certain and ſure by being ſo done. Attention muſt next be paid to lay down any bliſters, or places where the paint is leaving the ground : this is done by introducing, between the paint and the ground, ſome very ſtrong paſte of flour and water ; and the ſurface of the bliſtered paint being damped with a wet ſponge or bruſh, it may be preſſed with the hand home to the ground, to which it will then adhere.

“ All the unſound places being thus ſecured, care muſt be taken to clear the ſurface of any greaſe or dirt, as alſo of any particles of the paſte that may happen to be left on it. The next thing is, to determine the ſize of the painting meant to be taken off : If it is on a plain ſurface, a board of the ſize of the picture muſt be procured, not leſs than an inch in thickneſs, and framed together with well-ſeaſoned wood, in ſmall pannels, ſmooth and fluſh on one ſide. This done, a piece of fine open canvas muſt be provided, ſuch as the fineſt ſort uſed for hanging paper on ; which canvas is to be ſomewhat larger than the picture, and ſo ſewed together, and the ſeam ſo preſſed, that it be perfectly ſmooth and even. This is what Mr Salmon calls the ſecuring canvas ; which, being ſo prepared, is to be ſtuck on the ſurface of the picture with a paſte made of ſtrong beer, boiled till it is half reduced, and then mixed with a ſufficient quantity of flour to give it a very ſtrong conſiſtence. To large pictures on walls or ceilings, the canvas muſt for ſome time be preſſed, and rubbed with the hand as ſmooth as poſſible, working it from the middle to the outſide, ſo as to make it tolerably tight ; obſerving, as it dries, to preſs it, with the hand or a cloth, into any hollow or bruiſed places, ſo that it may adhere to every part of the painting: this done, it is left to dry; which it will generally do in a day or two. When dry, a ſecond canvaſs, of a ſtronger and cloſer ſort, and of the ſame ſize as the other, is in like manner to be attached on the top of the firſt. This laſt will want very little attention, as it will readily adhere to the firſt; and, being dry, attention muſt be paid to take off any ſmall knots or unevenneſs that may be upon the ſurface of it; which done, the whole ſhould be again covered with a thin paſte of ſize and whiting; which is to be pumiced over when dry, ſo as to make the whole perfectly ſmooth and even.

“The painting being thus ſecured, the board, already prepared to the ſize of the picture, is to be put with the ſmooth ſide againſt the ſurface thereof, ſo as exactly to cover as much as is intended to be transferred. The edges of the canvas, which, as before directed, is to be larger than the painting, are then to be pulled tight over, and cloſely nailed to the edge of the board. If the painting is large, and either on a ceiling or wall, the board muſt, by proper ſupports, be firmly fixed againſt it, ſo that it can readily be lowered down when the plaſter and painting are detached.

“The canvas and board being fixed, the painting is to be freed from the wall or ceiling, together with a certain portion of the plaſtering: this, with proper care and attention, may be readily done. If on a ceiling, the firſt thing is to make ſome holes through the plaſtering, round the outſide of the board and painting; and, with a ſmall ſaw, to ſaw the plaſtering from one hole to another, till the whole is diſunited from the other parts of the ceiling: this done, the workman muſt get at the upper ſide of the ceiling, where he muſt free the plaſtering from the laths, by breaking off the keys thereof, and with a chiſel cut out the laths; whereby the plaſtering, together with the picture, will be left reſting on the board and ſupports.

“If the painting is on a brick or ſtone wall, the wall muſt be cut away at top, and down the ſides of the painting; and then, by means of chiſels or ſaws in wooden handles, of different lengths, the wall muſt be cut away quite behind the painting; leaving the ſame, together with the plaſtering, reſting on the board. This operation may ſometimes be done with a ſaw; or, if the wall be not thick, nor the other ſide of much conſequence, the bricks or ſtones may be taken out from that ſide, leaving the plaſtering and painting as before. This laſt method (ſays the author) I have not practiſed: the other, of cutting away ſome part of the wall, I have, and ſee no difficulty, or very great labour, in the operation; but that, of courſe, muſt be various, according to the texture of the wall and mortar.

“If the paintings are on curved ſurfaces, ſuch as the coves of ceilings, then the only difference of operation is, that ſome ribs of wood muſt be cut out, and boarded ſmooth to the curve of the ſurface of the painting, and then fixed up thereto, in place of the before-deſcribed bearing-board; the painting is then to be freed, and left with the plaſtering, reſting on the bearers.

“For paintings on wainſcot or boards, the ſame ſecuring and proceſs is to be exactly followed; only that, as the wainſcot or board can always be cut to the ſize wanted, and laid horizontal, the ſecuring-canvas is to be ſtretched thereon, and turned over the edges of the ſame, till it is dry; after which, the edges are again to be turned up, and nailed to the board, in the ſame manner as with reſpect to paintings from walls.

“Having, as before deſcribed, in any of the aforementioned caſes, freed the paintings from their original places, you have got them ſecured to two thickneſſes of canvas, with their ſurfaces on the board prepared for that purpoſe; this being the caſe, they can readily be removed to any room or ſhop, to be finiſhed as follows: Having carried the painting into the ſhop or room, which ſhould be moderately warm and dry, but by no means overheated, lay the board on a bench or treſſels, ſo that the back of the picture be uppermoſt: the plaſtering or wood, as may happen, is then to be cleared away, leaving nothing but the body of paint, which will be firmly attached to the ſecuring-canvaſs. To perform this, a large raſp, a narrow plane, and chiſels, will be requiſite. This operation, though difficult to be deſcribed, would ſoon be learned by any one who ſhould make the attempt; nor is it very tedious; and being performed, the picture is ready to be attached to its new canvas, as follows.

“The painting being cleared, and lying on the board, the back thereof is to be painted three or four times over ſucceſſively, with any good ſtrong-bodied paint; leaving one coat to dry before another comes on: a day or two between each will generally be found ſufficient. Each of theſe coats, and particularly the firſt, ſhould be laid on with great care, taking but a ſmall quantity in the bruſh at a time, and laying it very thin. This precaution is neceſſary, to prevent any of the oil or paint from paſſing through any ſmall cracks or holes in the ſurface of the picture; as ſuch oil or paint would run into the paſte, and ſo attach the ſecuring-canvas to the picture, as to prevent its being afterwards got off. If any ſuch holes or cracks are obſerved, they ſhould be ſtopped up with the glue and whiting paſte, and the painting then repeated, till a complete coat is formed on the back of the picture. It is then ready for attaching to its canvas, which is done by ſpreading all over the picture a paſte made of copal varniſh, mixed with ſtiff white lead, and a ſmall quantity of any other old fat paint; all which being ſpread equally over with a pallet-knife, ſuch a canvas as the firſt ſecuring-canvas is laid thereon, and ſtrained and nailed round the edges of the board; in which ſtate it is left till it becomes tolerably dry: then a ſecond canvas, of a ſtronger ſort, muſt be in like manner attached on the firſt, and left till it is perfectly dry and hard. This generally takes about two months; and the longer the painting is left, the more ſecurely it will be attached to its canvas, and leſs liable to crack or fly therefrom. When ſufficiently dry, all the four canvaſſes are to be unnailed from the board, and the edges turned up the reverſe way, and nailed to a proper ſtretching-frame. This is done by unnailing from the board a part on each ſide at a time, and immediately nailing it to the ſtretching-frame, ſo as never to leave the canvas to crack or partially ſtretch, which would damage the picture. In this manner, by degrees, the cloths are entirely detached from the board, and firmly fixed on the ſtretching-frame. The ſuperfluous canvas, left larger than the frame, may then be cut off, and the wedges put in the frame, and moderately tightened up. There remains then only to clear the ſurface of the painting from the ſecuring-canvaſs; which is done by repeatedly waſhing the ſurface with a ſponge and moderately warm water. In doing this, no violence or force muſt be uſed; and, by frequent and gentle waſhings, the paſte will all be worked out with the ſponge. The edges of the outer canvas are then to be cut round, and ſtripped off: the other, next the ſurface of the picture, is to be ſerved in like manner; which done, nothing remains but to take the paſte clean off, and repair any defects: the picture will then be as ſtrong as if painted on the canvas.

"For taking pictures off walls, without taking the walls down, or cutting away more thereof than the plaſtering, the following proceſs is propoſed:

"The ſurface of the picture is to be firſt ſecured, in the manner before deſcribed; but inſtead of the plain board, a bearer ſhould be prepared with a convex ſurface, compoſed of ribs, boarded over, ſo as to form part of a cylinder, of not leſs than five feet radius, and as long as the height of the picture. This bearer being prepared, in order to apply it, a floor or platform ſhould be erected, and placed horizontally, with its ſurface level, and its edge immediately in contact with the bottom of the picture meant to be transferred. The uſe of this platform is for the above deſcribed bearer to reſt and move upon; which bearer ſhould be ſet on its end, with one edge in contact with the wall, at one ſide of the picture; conſequently the other edge will be at ſome diſtance from the wall, according to the ſize of the picture and convexity of the bearer. Being thus placed, the ſuperfluous edge of the ſecuring-canvas ſhould be turned over, and nailed to that edge of the bearer that is next the wall: This done, the operation of cutting away the plaſtering ſhould be begun; which may he done with the corner and end of a ſhort ſaw; ſawing between the brick-work and plaſtering, and leaving the thickneſs, or part of the thickneſs, of the plaſtering on the painting faſtened to the bearer. When this edge of the picture is freed, the whole height, for nine or ten inches under the edge of the bearer that is fartheſt from the wall, muſt then be gently forced nearer; conſequently the other edge, together with the painting and plaſter that is freed, will leave the wall, and give an opportunity of introducing the ſaw behind, and cutting away the ſame to a certain diſtance farther under; and, by repeating this, the whole of the picture will at length be freed, and left on the bearer. Each time the bearer is removed, and, as it were, rolled on the vertical ſurface of the wall, care muſt be taken to turn and nail the ſecuring-canvas on the top and bottom edges of the bearer, ſo as to ſecure the freed plaſtering and picture from moving about; and, laſtly, before the bearer and plaſtering be moved, to nail the other edge of the picture in the ſame way, which will ſecure the whole to the bearer. This done, the picture and bearer are at liberty to be moved to a proper place, in order to be freed from the remaining plaſter. The edges may then be unnailed; the painting and canvas ſlipped from this bearer on to a plain board; and the new canvas may be then put on; which is to remain till dry, as in other caſes.

"It may appear, that the bending of the canvas and plaſtering to the convex bearer will crack the plaſter, and damage the painting; but, from experience (ſays Mr Salmon) I have obſerved, that, to a curve of ſuch or even leſs radius, plaſtering will bend, without any viſible crack, even on the exterior part thereof; and that part next the bearer, not having occaſion, in bending, to extend its parts, will conſequently be much leſs liable to be diſturbed by ſuch bending."

In clearing the wood from the paintings, our author never made uſe of aquafortis, or any other liquid; the uſe of which he conceives would be very tedious, and attended with danger, leſt it ſhould get through the paint, and wet or damp the paſte by which the ſecuring canvaſs is fixed. In working off the wood, he generally made uſe of ſuch planes as by the joiners are called the *levelled rabbit-plane*, and *ſmall rounds*. By the corners of the former, and proper handling of the latter, the wood is cleared off without force or violence: even the ſmalleſt particles may, in general, be got off; although in ſome paintings, and in particular parts of others, he has met with places on which he thought it beſt to leave ſome particles, or fine ſplinters, of wood, but nothing more. Raſps, and ſometimes a fine chiſel, are uſeful, to clear off ſuch parts as may be in hollow places, or where particles of wood are left, as above. The time required will be various, according to the manner in which the painting was originally done; ſome being painted on boards previouſly prepared with a water colour; others immediately painted with oil on the wood. This laſt ſort is by much the moſt difficult; the other is more eaſy, as the previous preparation prevents the wood from imbibing the oil, and conſequently admits it to be more eaſily ſeparated.

PALILICUM, the ſame as Aldebaran, a fixed ſtar of the firſt magnitude, in the eye of the bull, or ſign Taurus.

PALLIFICATION, or Piling, in architecture, denotes the piling of the ground-work, or the ſtrengthening it with piles, or timber driven into the ground; which is practiſed when buildings are erected upon a moiſt or marſhy ſoil.

PALM, an ancient long meaſure, taken from the extent of the hand. See Palmus, *Encycl.*

PALMÆ, palms. See *Encyclopædia*. The ſubject is introduced here to notice a kind of palm, the product of North America, of which we have the following account by Dr Barton.

"There grows upon the river Mobile a ſpecies of palm, which is but little known to naturaliſts, but which promiſes to be an important article of food to man. It has no ſtalk or ſtem above ground. The leaves ſpread regularly all round, and when fully expanded are flabelliform. In the centre of theſe leaves is produced the receptacle of the fruit, which is of the form and ſize of a common ſugar-loaf. This receptacle conſiſts of a vaſt number of drupes, or berries, of the ſize and ſhape of common plums: each is covered with a fibrous, farinaceous, pulpy coating, of conſiderable thickneſs. This ſubſtance is ſaid to reſemble manna in texture, colour, and taſte; or, perhaps, it ſtill more reſembles moiſt brown ſugar, with particles of loaf-ſugar mixed with it. It is a moſt delicious and nouriſhing food, and is diligently ſought after in the places where it grows. Upon firſt taſting it, it is ſomewhat bitter and pungent.

PANORAMA, a word derived from παν and οραμα; and therefore employed of late to denote a painting, whether in oil or water colours, which repreſents an entire view of any country, city, or other natural objects, as they appear to a perſon ſtanding in any ſituation, and turning quite round. To produce this effect, the painter or drawer muſt fix his ſtation, and delineate correctly and connectedly every object which preſents itſelf to his view as he turns round, concluding his drawing by a connection with where he began. He muſt obſerve the lights and ſhadows, how they fall, and perfect his piece to the beſt of his abilities. There muſt be a circular building or framing erected, on which this drawing or painting may be performed; or the ſame may be done on canvas, or other materials, and fixed or ſuſpended on the ſame building or framing, to anſwer the purpoſe complete. It muſt be lighted entirely from the top, either by a glazed dome, or otherwiſe as the artiſt may think proper. There muſt be an incloſure within the ſaid circular building or framing, which ſhall prevent an obſerver going too near the drawing or painting, ſo as it may, from all parts it can be viewed, have its proper effect. This incloſure may repreſent a room, or platform, or any other ſituation, and may be of any form thought moſt convenient; but the circular form is particularly recommended. Of whatever extent this inſide incloſure may be, there muſt be over it (ſupported from the bottom, or ſuſpended from the top) a ſhade or roof; which, in all directions, ſhould project ſo far beyond this incloſure, as to prevent an obſerver from ſeeing above the drawing or painting when looking up; and there muſt be without this incloſure another interception, to repreſent a wall, paling, or other interception, as the natural objects repreſented, or fancy, may direct, ſo as effectually to prevent the obſerver from ſeeing below the bottom of the drawing or painting; by means of which interception, nothing can be ſeen on the outer circle but the drawing or painting intended to repreſent nature. The entrance to the inner incloſure muſt be from below, a proper building or framing being erected for that purpoſe, ſo that no door or other interruption may diſturb the circle on which the view is to be repreſented. And there ſhould be, below the painting or drawing, proper ventilators fixed, ſo as to render a current circulation of air through the whole; and the inner incloſure may be elevated, at the will of an artiſt, ſo as to make obſervers, on whatever ſituation he may wiſh they ſhould imagine themſelves, feel as if really on the very ſpot.

PAPER is an article of ſuch importance, and at preſent* of ſo enormous a price, that no improvement in its manufacture ſhould paſs unnoticed in a work of this nature. The diſcovery made in France by M. Bertholet of the efficacy of oxy-muriatic acid in expediting the proceſs of BLEACHING (ſee that article in this *Suppl.*), has contributed eſſentially to facilitate the manufactures, not only of cotton and linen cloths, but alſo of paper, of which it has even increaſed the materials. Formerly writing paper could be made of *unprinted* linen alone; but by means of the proceſs of M. Bertholet even printed linen may be made into the fineſt and whiteſt paper. In the year 1795 a patent was granted to Mr Elias Carpenter of Bermondſay, Surrey, for a method of bleaching paper of ſuch materials in the *water-leaf* or *ſheet*, and ſizing it without drying.

In the preparation of the pulp, the coarſer rags are to be macerated for two or three days in a cauſtic alkaline ley, and wrought into ſheets of paper in the uſual way; a ſtrong wooden box or trough is then to be procured, of a ſize proportioned to that of the paper, lined on the inſide with white paint, and furniſhed with ſeveral ſtages of croſs bars of glaſs: the bottom of the box is to be covered with a ſtratum about one inch deep of cauſtic ley, and the paper laid by quarter reams, or leſs, acroſs the glaſs bar. A hole muſt be made in the box to admit the beak of an earthen-ware retort, into which muſt be put mangan eſe and ſea ſalt, in powder, ſulphuric acid, and an equal quantity of water impregnated with the ſteams of burning ſulphur (ſulphureous acid). The cover of the box is to be made air-tight by luting or ſlips of paper dipped in paſte. The apparatus being thus prepared, the belly of the retort is to be plunged in water, kept boiling, and in a ſhort time the oxy-muriatic gas will be driven into the box, will penetrate the paper, and render it of a dazzling whiteneſs, while the alkaline ley at the bottom will, by gradually abſorbing it, prevent its becoming ſo concentrated as to deſtroy or injure the texture of the paper. From three to four pounds of ſulphuric acid will ſuffice for one hundred weight of paper, and the operation will be completed in about eight hours. The ſheets as they are taken out of the box are to be ſized with the following mixture:

To 1 cwt. of clippings of ſkin add 14 lb. of alum, 7 of calcined vitriol, and 1 lb. of gum arabic, with a ſufficient quantity of water to ſize 50 reams of fools-cap.

The ſame method will ſerve equally well to clean engravings or printing; for though the oxy-muriatic acid diſcharges all ſtains, dirt, &c. yet it is incapable of acting on printers ink.

This, however, is not the only improvement in the manufacture of paper derived from modern chemiſtry. In Crell's *Chemical Annals* for the year 1797, we have an account of ſome curious experiments made by M. L. Brugnatelli, with the view of rendering

PAPER incombuſtible, and the writing on it, of courſe, indeſtructible by fire. Of all the ſubſtances which he tried, he found the liquor of flints the moſt proper to ſecure paper from deſtruction by fire. He dipped a ſheet of paper ſeveral times in the above liquor freſh made, or daubed it ſeveral times over the whole paper with a hair bruſh, and dried it in the ſun or in an oven. Paper prepared in this manner loſt ſome of its ſoftneſs, became a little rougher than before, and acquired a lixivious cauſtic taſte. In other reſpects it was not different from common white paper. When this paper was laid upon glowing coals, it did not burn like common paper, but became red, and was converted to a coal, which however did not fall into aſhes like the coal of common paper, ſo that it might therefore be conſidered as petrified paper. This coal, however, is exceedingly friable; for when it is taken between the fingers, or preſſed together in any manner whatever, it drops to pieces. Still the diſcovery muſt be a valuable one, if there be any kind of ink of ſuch a nature as that the characters written with it continue viſible on this coal. Such an ink M. Brugnatelli made by combining diſſolved nitrite of zinc with common ink; and found, that the colour of this mixture, though it appeared ſomewhat pale on common paper, became ſo dark on prepared paper, that words written with it appeared more conſpicuous than words written with common ink. When the paper was burnt, or reduced to a coal, thoſe characters were ſo viſible, in a clear *white* colour on a *dark* ground, that they could be read with as much eaſe as characters written with the beſt ink on

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* 1800.

white paper. If the ingenious author ſucceed in his attempts to diſcover a method of rendering his prepared paper leſs friable when burnt, his diſcovery will be one of the moſt important of the preſent age.

PARABOLIC Conoid, is a ſolid generated by the rotation of a parabola about its axis. This ſolid is equal to half its circumſcribed cylinder; and therefore if the baſe be multiplied by the height, half the product will be the ſolid content.

Parabolic Pyramidoid, is a ſolid figure, thus named by Dr Wallis from its geneſis or formation, which is thus: Let all the ſquares of the ordinates of a parabola be conceived to be ſo placed, that the axis ſhall paſs perpendicularly through all their centres; then the aggregate of all theſe planes will form the parabolic pyramidoid. This figure is equal to half its circumſcribed parallelopipedon. And therefore the ſolid content is found by multiplying the baſe by the altitude, and taking half the product; or the one of theſe by half the other.

Parabolic Space, is the ſpace or area included by the curve line and baſe or double ordinate of the parabola.

Parabolic Spindle, is a ſolid figure conceived to be formed by the rotation of a parabola about its baſe or double ordinate.

Parabolic Spiral, is a curve ariſing from the ſuppoſition that the common or Apollonian parabola is bent or twiſted till the axis come into the periphery of a circle, the ordinates ſtill retaining their places and perpendicular poſitions with reſpect to the circle, all theſe lines ſtill remaining in the ſame place. This figure is ſometimes called the *Helicoid parabola*.

PARABOLOIDES, parabolas of the higher orders. The equation for all curves of this kind being $a^{m-n} x^{n} = y^{m}$, the proportion of the area of any one to the complement of it to the circumſcribing parallelogram, will be as *m* to *n*.

PARACENTRIC Motion, denotes the ſpace by which a revolving planet approaches nearer to, or recedes farther from, the ſun, or centre of attraction.

Paracentric Solicitation of Gravity, is the ſame as the vis centripeta.

PARACHUTE, a kind of large and ſtrong umbrella, contrived to break a perſon's fall from an air-balloon, ſhould any accident happen to the balloon at a high elevation. This contrivance was firſt thought of by Blanchard, who at different times, by means of the parachute, let fall from his balloon dogs and other animals. He ventured even to deſcend in this manner himſelf; but, whether from the bad conſtruction of his parachute, or from falling among trees, he had the misfortune to break one of his legs. Citizen Garnerin, as he chooſes to be called, was more ſucceſsful. On the 21ſt of October 1797, he aſcended from the garden de Mauſſeux at half paſt five in the evening; between the balloon and the car, in which he ſat, was placed the parachute, half opened, and forming a kind of tent over the aërial traveller; and when the whole apparatus was at a conſiderable height, he ſeparated the parachute and car from the balloon. The parachute unfolding itſelf, was, by his weight and that of the car, drawn of courſe towards the earth. Its fall was at firſt ſlow and vertical; but ſoon afterwards it exhibited a kind of balancing or vibration, and a rotation gradually increaſing, which might be compared with that of a leaf falling from a tree. The aëronaut, however, reached the ground unhurt.

This parachute was of cloth, and its diameter, when unfolded, about twenty-five feet. To uſe ſuch inſtruments with ſucceſs, it is neceſſary that the car be ſuſpended at a conſiderable diſtance from the parachute, ſo as that the centre of gravity of the whole ſhall be vertically below the centre of reſiſtance made by the air to the deſcent of the parachute; for if the car be otherwiſe placed, it is evident that the parachute will incline to one ſide, deſcend obliquely, oſcillate, and the ſmalleſt irregularity in its figure will cauſe it to turn round its vertical axis.

PARAGUATAN, a kind of wood which grows in Guiana, and promiſes to be of great utility as a dye ſtuff. We have ſeen no botanical deſcription of the tree; but from the report made to the Council of Trade and Mines, by D. Dominique Garcia Fernandez, inſpector of coinage, we learn that its bark, boiled in water, affords a coloured extract which reſiſts the agency of acids for a longer time than brazil or logwood; that the colour may be revived by means of alkalies, after it has been deſtroyed by combination with acids; that vinegar, lemon-juice, and tartar, render this colour more brilliant, while they entirely deſtroy the colours of brazil and logwood; that the fecula of the bark of paraguatan fixes and attaches itſelf to wool, cotton, and ſilk; and that the colour is brighter on ſilk than on wool, and brighter on wool than on cotton. The ſame fecula dried is afterwards ſoluble in alcohol, to which it communicates a tinge ſimilar to that afforded by cochineal; but it muſt be confeſſed, that the colour obtained from paraguatan has not the force of that of cochineal, though it is ſuperior to thoſe of madder, brazil wood, and logwood. From theſe facts D. Fernandez conſiders the paraguatan as one of the moſt valuable productions which America furniſhes to Spain.

PARALLAX (ſee *Encycl.*) is uſed, not only in aſtronomy, but alſo in levelling, for the angle contained between the line of true level, and that of apparent level. And, in other branches of ſcience, for the difference between the true and apparent places.

PARALLEL Ruler, is a mathematical inſtrument, conſiſting of two equal rulers, either of wood or metal, connected together by two ſlender croſs bars or blades of equal length, moveable about the points of junction with the rulers. There are other forms of the inſtrument; ſome, for inſtance, having the two blades croſſing in the middle, and fixed only at one end of them, the other two ends ſliding in grooves along the two rulers, &c.

The uſe of this inſtrument is obvious. For the edge of one of the rulers being applied to any line, the other opened to any extent will be always parallel to the former; and conſequently any parallels to this may be drawn by the edge of the ruler, opened to any extent.

PARALLELS, or Places of Arms, in a ſiege, are deep trenches, 15 or 18 feet wide, joining the ſeveral attacks together; and ſerving to place the guard of the trenches in, to be at hand to ſupport the workmen when attacked. There are uſually three in an attack: the firſt is about 600 yards from the covert-way, the ſecond between 3 and 400, and the third near or on the glacis. It is ſaid they were firſt invented or uſed by Vauban.

PARALLELISM of the Earth's Axis, is that invariable ſituation of the axis, in the progreſs of the earth thro' the annual orbit, by which it always keeps parallel to itſelf; ſo that if a line be drawn parallel to its axis, while in any one poſition, the axis, in all other poſitions or parts of the orbit, will always be parallel to the ſame line.

PARAMETER, a certain conſtant right line in each of the three conic ſections; otherwiſe called alſo *latus rectum*.

PARAMARIBO, the capital of the Dutch ſettlement at Surinam, is ſituated on the right ſide of the beautiful river Surinam, at about 16 or 18 miles diſtance from its mouth. It is built upon a kind of gravelly rock, which is level with the reſt of the country, in the form of an oblong ſquare; its length is about a mile and a half, and its breadth about half as much. All the ſtreets, which are perfectly ſtraight, are lined with orange, ſhaddock, tamarind, and lemon trees, which appear in everlaſting bloom; while, at the ſame time, their branches are weighed down with the richeſt cluſters of odoriferous fruit. Neither ſtone nor brick is made uſe of here for pavement; the whole being one continued gravel, not inferior to the fineſt garden walks in England, and ſtrewed on the ſurface with ſea-ſhells. The houſes, which are moſtly of two and ſome of three ſtories high, are all built of fine timber, a very few excepted; moſt of the foundations are of brick, and they are roofed with thin ſplit boards, called *ſhingles*, inſtead of ſlates or tiles. Windows are very ſeldom ſeen in this country, glaſs being inconvenient on account of the heat; inſtead of which they uſe gauze frames: ſome have only the ſhutters, which are kept open from ſix o'clock in the morning until ſix at night. As for chimneys, there are none in the colony; no fires being lighted except in the kitchens, which are always built at ſome diſtance from the dwelling-houſe, where the victuals are dreſſed upon the floor, and the ſmoke let out by a hole made in the roof: theſe timber houſes are, however, very dear in Surinam, one of them having coſt above L. 15,000 ſterling. There is no ſpring water to be met with in Paramaribo; moſt houſes have wells dug in the rock, which afford but a brackiſh kind of beverage, only uſed for the negroes, cattle, &c. and the Europeans have reſervoirs or ciſterns, in which they preſerve rain-water for their own conſumption; thoſe of nicer taſte let it firſt drop through a filtering ſtone into large jars or earthen pots, made by the native Indians on purpoſe, which they barter at Paramaribo for other commodities. The inhabitants of this country, of every denomination, ſleep in hammocks, the negro ſlaves excepted, who moſtly lie on the ground: the hammocks uſed by thoſe in ſuperior ſtations are made of cotton, ornamented with rich fringe; theſe are alſo made by the Indians, and ſometimes worth above twenty guineas; neither bedding nor covering is neceſſary, except an awning to keep off the muſquitoes. Some people indeed lie on bedſteads; in that caſe they are ſurrounded, inſtead of curtains, with gauze pavilions, which admit the air freely, and at the ſame time keep off the ſmalleſt inſect. The houſes in general at Paramaribo are elegantly furniſhed with paintings, gilding, cryſtal chandeliers, china jars, &c.; the rooms are never papered or plaſtered, but beautifully wainſcotted with cedar, and Brazil, and mahogany wood.

The number of buildings in Paramaribo is computed at about 1400, of which the principal is the governor's palace, whence there is a private paſſage through the garden which communicates with Fort Zelandia. This houſe, and that of the commandant, which has lately been burnt, were the only brick-buildings in the colony. The town-hall is an elegant new building, and covered with tiles; here the different courts are held, and underneath are the priſons for European delinquents, the military excepted, who are confined in the citadel of Fort Zelandia. The Proteſtant church, where divine worſhip is performed both in French and Low Dutch, has a ſmall ſpire with a clock; beſides which there is a Lutheran chapel, and two elegant Jewiſh ſynagogues, one German the other Portugueſe. Here is alſo a large hoſpital for the garriſon, and this manſion is never empty. The military ſtores are kept in the fortreſs, where the ſociety ſoldiers are alſo lodged in barracks, with proper apartments for ſome officers. The town of Paramaribo has a noble road for ſhipping, the river before the town being above a mile in breadth, and containing ſometimes above 100 veſſels of burden, moored within a piſtol-ſhot of the ſhore. Before Holland became a province of France, and thereby loſt her trade, there were ſeldom fewer than 80 ſhips at Paramaribo, loading coffee, ſugar, cocao, cotton, and indigo, for the mother country, including alſo the Guinea-men that bring ſlaves from Africa, and the North American and Leeward Iſland veſſels, which bring flour, beef, pork, ſpirits, herrings, and mackarel ſalted, ſpermaceti candles, horſes, and lumber; for which they receive chiefly molaſſes to be diſtilled into rum. This town is not fortified, but is bounded by the river on the ſouth eaſt; by a large ſavannah on the weſt; by an impenetrable wood on the north-eaſt; and is protected by Fort Zelandia on the eaſt. This citadel is only ſeparated from the town by a large eſplanade, where the troops parade occaſionally. The fort is a regular pentagon, with one gate fronting Paramaribo, and two baſtions which command the river; it is very ſmall but ſtrong, being made of rock or hewn ſtone, ſurrounded by a broad foſſe well ſupplied with water, beſides ſome outworks. On the eaſt ſide, fronting the river, is a battery of 21 pieces of cannon. On one of the baſtions is a bell, which is ſtruck with a hammer by the centinel, who is directed by an hour-glaſs. On the other is planted a large enſign-ſtaff, upon which a flag is hoiſted upon the approach of ſhips of war, or on public rejoicing days. The walls are ſix feet thick, with embraſures, but no parapet.

Paramaribo is a very lively place, the ſtreets being generally crowded with planters, ſailors, ſoldiers, Jews, Indians, and Negroes, while the river is covered with canoes, barges, &c. conſtantly paſſing and repaſſing like the wherries on the Thames, often accompanied with bands of muſic; the ſhipping alſo in the road adorned with their different flags, guns firing, &c. not to mention the many groupes of boys and girls playing in the water, altogether form a pleaſing appearance; and ſuch gaiety and variety of objects ſerve, in ſome meaſure, to compenſate for the many inconveniences of the climate. Their carriages and dreſs are truly magnificent; ſilk embroidery, Genoa velvets, diamonds, gold and ſilver lace, being daily worn, and even the maſters of trading ſhips appears with buttons and buckles of ſolid gold. They are equally expenſive at their tables, where every thing that can be called delicate is produced at any price, and ſerved up in plate and china of the neweſt faſhion, and moſt exquiſite workmanſhip. But nothing diſplays the luxury of the inhabitants of Surinam more than the number of ſlaves by whom they are attended, often twenty or thirty in one family. White ſervants are ſeldom to be met with in this colony.

The current money are ſtamped cards of different value, from five ſhillings to fifty pounds: gold and ſilver is ſo ſcarce, that the exchange premium for ſpecie is often above 10 *per cent.* A baſe Dantzic coin called a *bit*, value ſomething leſs than ſixpence, is alſo current in Surinam. Engliſh and Portugueſe coin are ſometimes met with, but moſtly uſed as ornaments by the Mulatto, Samboe, Quaderoon, and Negro girls. The Negro ſlaves never receive any paper money; for as they cannot read, they do not underſtand its value; beſides, in their hands it would be liable to many accidents, from fire or children, and particularly from the rats, when it becomes a little greaſy.

This town is well ſupplied with proviſions, *viz.* butchers meat, fowls, fiſh, and veniſon. Vegetables in particular the country abounds with; beſides the luxuries peculiar to this climate, they import whatever Europe, Africa, and Aſia can afford. Proviſions, however, are exceſſively dear in general, eſpecially thoſe imported, which are moſtly ſold by the Jews and maſters of ſhips. The firſt enjoy extraordinary privileges in this colony; the latter erect temporary warehouſes for the purpoſe of trade, during the time their ſhips are loading with the productions of the climate. Wheat flour is ſold from four-pence to one ſhilling per pound; butter, two ſhillings; butcher's meat never under one ſhilling, and often at one ſhilling and ſixpence; ducks and fowls from three to four ſhillings a couple. A ſingle turkey has ſometimes coſt one guinea and a half; eggs are ſold at the rate of five, and European potatoes twelve, for ſixpence. Wine three ſhillings a bottle. Jamaica rum a crown a gallon. Fiſh and vegetables are cheap, and fruit almoſt for nothing.

PARIS (Francis), a man more famous after his death than during his life, by the miracles which were ſaid to be performed at his tomb. He is generally known by the name of Abbé Paris; and his pretended miracles, with others of like manufacture, have furniſhed deiſtical writers, and Mr Hume in particular, with a kind of argument againſt the reality of the miracles of which we have an account in the Goſpel. It is merely that we may ſtate his pretenſions fairly, that we have introduced him to the notice of our readers; for in every other reſpect he is wholly unworthy of their regard. He was the ſon of a counſellor in Parliament, and had the proſpect, if he had choſen it, of ſucceeding to his father's appointment; but he choſe rather to become an eccleſiaſtic, and he became a very zealous one. He gave up all his poſſeſſions to his brother, refuſed preferment intended for him by the cardinal de Noailles, devoted himſelf entirely to retirement, and made ſtockings for his own ſupport, and for the aſſiſtance of the poor. He died, perhaps in conſequence of his rigorous mode of life, May 1. 1727, at the age of only 37. His brother raiſed a monument to him in the ſmall churchyard of St Medard, to which the poor and the pious ſoon began to flock; and after a time it was reported, that, in conſequence of their prayers at that tomb, ſome ſick perſons had received cures. As Paris had been a rigorous Janſeniſt, this was a fine opportunity for that ſect to gain credit to their cauſe; the miracles were therefore multiplied, and a variety of perſons affected the moſt ſingular convulſions.

The minds of the people becoming inflamed by theſe extravagancies, the court found it neceſſary to ſhut up the churchyard, which was done on the 27th of January 1732. On this occaſion, ſome profane wit wrote upon the wall of the place,

De par le Roy, defenſe a Dieu,
De faire miracles en ce lieu.

The convulſions were continued, for a little while, in private houſes, but by degrees the matter ſubſided, and the Abbé Paris was forgotten.

The diſtinction between miracles exhibited to ſerve a party, and atteſted only by thoſe who are zealous in its ſupport, and miracles performed in the ſight of unbelievers, who, in ſpite of their deep-rooted prejudices, were converted by them, is too ſtriking to be overlooked by any, but thoſe who are deſirous of drawing a falſe and impious parallel; yet has Mr Hume dared to repreſent the miracles performed at the tomb of this ſaint as outvying in number, nature, and evidence, the miracles of Chriſt and his apoſtles—with what truth, the following obſervations will ſhew:

1ſt, It was often objected by the enemies of the ſaint, and the objection was never confuted by his friends, that the *proſtrations* at his ſepulchre, like animal magnetiſm more lately, *produced* more diſeaſes than they *cured*. Such, ſurely, was not the nature of our Saviour's miracles.

2dly, Though the crowds of ſick and infirm perſons who flocked to the tomb for relief were, by all accounts, innumerable; yet all the cures, of which the zealous hiſtorian of the Miracles could procure vouchers, amounted only to NINE! Now, were thouſands, and ten thouſands of diſeaſed perſons to apply to ſome circumforaneous quack, in full aſſurance of his extraordinary abilities and ſkill in phyſic, could it ſurpriſe any perſon, if the diſtempers of *eight* or *nine* of them ſhould take a favourable turn while they were under a courſe of his uſeleſs medicines?

3dly, We do not read that of thoſe nine who were cured by the dead Abbé, the greater part were Jeſuits and enemies to the Janſeniſts; whereas the greater part of our Saviour's miracles were performed upon unconverted Jews, and one of them upon the ſervant of the high prieſt, who was thirſting for his blood.

4thly, The cures reported to have been performed at the grave of Paris were all ſuch as might have been accompliſhed by natural means. Thus, a Spaniard who had loſt one eye, and was diſtreſſed with an inflammation in the other, had the inflamed eye gradually cured, but not the loſt eye reſtored. Another perſon having pricked his eye with an awl, loſt the ſight of it in conſequence of the aqueous humour dropping out; but his ſight was reſtored *whilſt* he was paying his devotions to the Abbé—and ſo it would have been while he was curſing the Abbé, had he continued his execrations for a ſufficient length of time.

5thly, None of the cures ſaid to have been performed were *inſtantaneous*. *All* the worſhippers at the tomb perſiſted for *days*, ſeveral of them for *weeks*, and ſome for *months*, daily imploring the interceſſion of the Abbé *before* they received relief from their complaints.

6thly, Moſt of the devotees had been uſing *medicines* before they applied to the ſaint, and continued to uſe them *during the whole time* of their application; whilſt it is confeſſed that the diſtempers of others had *abated* before they determined to ſolicit his help.

7thly, Some of the cures atteſted were *incomplete*, and only of a temporary duration. Thus, the Spaniard was relieved only from the moſt inconſiderable part of his complaint, and that too but for a very ſhort period; for ſoon after his return home he relapſed into his former malady, as was fully atteſted by certificates and letters from Madrid. All this has been completely proved by the Archbiſhop of Sens; who in his *Paſtoral Inſtruction*, publiſhed at the time the miracles were making a noiſe, has,

8thly, Clearly detected the deceit and little artifices by which thoſe pretended miracles were ſo long ſupported. To that work we refer our readers; requeſting them, after they have read it, to compare the evidence for the miracles of Paris with the evidence which in the article MIRACLE (*Encycl.*) we have ſtated for the reality of the Goſpel miracles, and to judge for themſelves with the impartiality of philoſophers.

Paris wrote a few very indifferent books of annotations on the Epiſtles to the Romans, to the Galatians, and the Hebrews; but few have ever read them, nor would they have reſcued the author from oblivion, without the aid of his lying wonders.

PARKHURST (the Rev. John), was the ſecond ſon of John Parkhurſt, Eſq; of Cateſby in Northamptonſhire. His mother was Ricarda Dormer, daughter of Judge Dormer. He was born in June 1728, was educated at the ſchool of Rugby in Warwickſhire, and was afterwards of Clare-hall, Cambridge; B. A. 1748, M. A. 1752; and many years fellow of his college.

Being a younger brother, he was intended for the church; but not long after his entering into holy orders his elder brother died. This event made him the heir of a very conſiderable eſtate; though, as his father was ſtill living, it was ſome time before he came into the full poſſeſſion of it; and when he did come into the poſſeſſion of it, the acquiſition of fortune produced no change on his manners or his purſuits. He continued to cultivate the ſtudies becoming a clergyman; and from his family connections, as well as from his learning and piety, he certainly had a good right to look forward to preferment in his profeſſion; but betaking himſelf to retirement, and to a life of cloſe and intenſe ſtudy, he ſought for no preferment; and, according to the author of the biographical ſketch of him publiſhed in the Gentleman's Magazine, he lived not in an age when merit was urged forward. Yet, in the capacity of a curate, but without any ſalary, he long did the duty, with exemplary diligence and zeal, in his own chapel at Cateſby, which, after the demolition of the church of the nunnery there, ſerved as a pariſh-church, of which alſo he was the patron.

When, ſeveral years after, it fell to his lot to exerciſe the right of preſentation, he was ſo unfaſhionable as to conſider church-patronage as a truſt rather than a property; and, accordingly, reſiſting the influence of intereſt, favour, and affection, preſented to the vicarage of Epſom, in Surrey, the Rev. Jonathan Boucher, who ſtill holds it. This gentleman was then known to him only by character; but having diſtinguiſhed himſelf in America, during the revolution, for his loyalty, and by teaching the unſophiſticated doctrines of the church of England to a ſet of rebellious ſchiſmatics at the peril of his life, Mr Parkhurſt thought, and juſtly thought, that he could not preſent to the vacant living a man who had given better proofs of his having a due ſenſe of the duties of his office.

In the year 1754, Mr Parkhurſt married Suſanna Myſter, daughter, and, we believe, heireſs of John Myſter, Eſq; of Epſom. It was thus that he became patron of the living which he beſtowed on Mr Boucher. This lady died in 1759, leaving him a daughter and two ſons; both the ſons are now dead. In the year 1761, he married again Millicent Northey, daughter of Thomas Northey, Eſq; by whom he had one daughter, now married to the Rev. Joſeph Thomas.

In the year 1753, he began his career of authorſhip, by publiſhing, in 8vo, "A friendly Addreſs to the Rev. Mr John Weſley, in relation to a principal Doctrine maintained by him and his Aſſiſtants." This work we have not ſeen; but though we have no doubt of its value, we may ſafely ſay that it was of very little importance, when compared with his next publication, which was "An Hebrew and Engliſh Lexicon, without Points; to which is added, a methodical Hebrew Grammar, without Points, adapted to the uſe of Learners, 1762," 4to. To attempt a vindication of all the etymological and philoſophical diſquiſitions which are ſcattered through this dictionary, would be very fruitleſs; but it is not perhaps too much to ſay, that we have nothing of the kind equal to it in the Engliſh language. He continued, however, to correct and improve it; and in 1778 another edition of it came out much enlarged, and a third in 1792.

His philological ſtudies were not confined to the Hebrew language; for he publiſhed a Greek and Engliſh Lexicon to the New Teſtament; to which is prefixed, a plain and eaſy Greek Grammar, 1769, 4to; a ſecond edition, 1794: and at his death there was in the preſs a new edition of both theſe lexicons, in a large 8vo, with his laſt corrections; for he continued to reviſe, correct, add to, and improve, theſe works, till within a few weeks of his death. As, from their nature, there cannot be ſuppoſed to be any thing in dictionaries that is particularly attractive and alluring, this continued increaſing demand for theſe two ſeems to be a ſufficient proof of their merit.

He publiſhed, "The Divinity and Pre-exiſtence of our Lord and Saviour Jeſus Chriſt, demonſtrated from Scripture; in Anſwer to the firſt Section of Dr Prieſtley's Introduction to the Hiſtory of early Opinions concerning Jeſus Chriſt; together with Strictures on ſome other Parts of the Work, and a Poſtſcript relating to a late Publication of Mr Gilbert Wakefield, 1787," 8vo. This work was very generally regarded as completely performing all that its title-page promiſed; and accordingly the whole edition was ſoon ſold off. The brief, evaſive, and very unſatisfactory notice taken of this able pamphlet by Dr Prieſtley, in "A

"Letter to Dr Horne," &c. ſhewed only that he was unable to anſwer it.

Mr Parkhurſt was a man of very extraordinary independency of mind and firmneſs of principle. In early life, along with many other men of diſtinguiſhed learning, it was alſo objected to him, that he was an Hutchinſonian; and on this account alone, in common with them, it has been ſaid that he was neglected and ſhunned.

There is not, in the hiſtory of the times, ſays the biographer already quoted, a circumſtance more difficult to be accounted for than the unmerited, but increaſing, diſcountenance ſhewn to thoſe perſons to whom Hutchinſonianiſm was then objected. Methodiſts, Papiſts, and ſectaries of any and of every name, all ſtood a better chance of being noticed and eſteemed than Hutchinſonians. Had it even been proved that the few peculiar tenets by which they were diſtinguiſhed from other Chriſtians were erroneous, the oppoſition they experienced might have been deemed *hard meaſure*, becauſe even their opponents allowed their principles to be inoffenſive, and themſelves to be learned.

Is this a fair ſtate of the caſe? We think not. The early Hutchinſonians had imbibed all the peculiar notions of their maſter, and maintained them with a degree of acrimony which would have diſgraced any cauſe. Being in general very little acquainted with the higher mathematics, as Mr Hutchinſon himſelf ſeems likewiſe to have been, they cenſured dogmatically works which, without that knowledge, they could not fully underſtand; whilſt they maintained, with equal dogmatiſm, as matters of fact, hypotheſes, which a moderate ſhare of mathematical ſcience would have ſhewn them to be impoſſible. Had they ſtopt here, no harm would have been done; they might have enjoyed their favourite notions in peace: but unfortunately they accuſed of Atheiſm, Deiſm, or Socinianiſm, all who thought not exactly as *they* thought, both in natural philoſophy and in theology. Becauſe Newton and Clarke had demonſtrated that the motions of the planets cannot be the effect of the impulſion of any material fluid, Hutchinſon, with ſome of his followers, affirmed, that theſe two illuſtrious men had entered into a ſerious deſign to overturn the Chriſtian religion, and eſtabliſh in England the worſhip of the Heathen Jupiter, or the Stoical *anima mundi*. Becauſe the Biſhops Pearſon, Bull, and others, who had uniformly been conſidered as the ableſt defenders of the Catholic faith, thought not exactly as Hutchinſon thought of the filiation of the Son of God, they were condemned by the pupils of his ſchool as *Arians*, or at leaſt *Semi-arians;* and the writer of this ſketch has heard a living Hutchinſonian pronounce the ſame cenſure, and for the ſame reaſon, on the preſent illuſtrious Biſhop of Rocheſter, and the no leſs illuſtrious Whitaker.

That men, who thus condemned all that before them had been deemed great and good in phyſical ſcience and Chriſtian theology, ſhould meet with ſome diſcountenance while they continued of ſuch a ſpirit, needs not ſurely excite much wonder; but that the diſcountenance is increaſing, we believe not to be true. The Hutchinſonians, as ſoon as they became leſs violent againſt thoſe who differed from them, had their ſhare of preferment, in proportion to their number, with others; and we doubt not they will continue to have it, while they allow that a man may be no heretic, though he believe not Mr Hutchinſon to have been infallible. The late excellent Biſhop Horne was an avowed Hutchinſonian, though not an outrageous one like Julius Bate; and we have been told, and have reaſon to believe, that the Biſhop of St Aſaph is likewiſe a moderate favourer of the ſame ſyſtem. There may be others on the epiſcopal bench; but perhaps two out of twenty-ſix is the full proportions of Hutchinſonian divines of eminence in England. It is true that Mr Parkhurſt was a man of great learning and great worth; but before we attribute his want of preferment in the church to his Hutchinſonianiſm, it is incumbent upon us to ſay why Mr Whitaker, who is no Hutchinſonian, is ſtill nothing more than the rector of Ruan-Lanyhorne.

Mr Parkhurſt, however, was not, if his biographer deſerves credit, a thorough-paced Hutchinſonian; for though he continued to read Hutchinſon's writings as long as he read at all, he was ever ready to allow, that he was oftentimes a confuſed and bad writer, and ſometimes unbecomingly violent. To have been deterred from reading the works of an author, who, with all his faults, certainly throws out many uſeful hints, for fear of being thought a Hutchinſonian, would have betrayed a puſillanimity of which Mr Parkhurſt was incapable. What he believed he was not afraid to profeſs; and never profeſſed to believe any thing which he did not very ſincerely believe. An earneſt lover of truth, he ſought it where only it is to be found—in the Scriptures (A) The ſtudy of theſe was at once the buſineſs and the pleaſure of his life; from his earlieſt to his lateſt years, he was an hard ſtudent; and had the daily occupations of every 24 hours of his life been portioned out, as it is ſaid thoſe of king Alfred were, into three equal parts, there is reaſon to believe that a deficiency would rarely have been found in the eight hours allotted to ſtudy. What the fruits have been of a life ſo conducted, few theologians, it is preſumed, need to be informed, it being hardly within the ſcope of a ſuppoſition, that any man will now ſit down to the ſtudy of the Scriptures without availing himſelf of the aſſiſtance to be obtained from his learned labours. Theſe labours ceaſed at Epſom in Surrey, where this great and good man died, on March the 21ſt, 1797. Beſides the works which we have mentioned, there is in the Gentleman's Magazine, for Auguſt 1797, a curious letter of his on the Confuſion of Tongues at Babel.

Mr Parkhurſt's character may be collected with tolerable accuracy even from this imperfect ſketch of his life. His notions of church patronage do him honour; and as a farther inſtance of the high ſenſe he entertained

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(A) This is vague language, which is the ſource of much uſeleſs controverſy, and therefore ought to be avoided. If by *truth*, in this paſſage, be meant *religious* truth, we admit the aſſertion in the only ſenſe in which we think it can have been made. If the author means *all* truth, he writes nonſenſe; for the Scriptures treat not of *geometry* or *algebra*, where truth is certainly to be found; and *we think* that they have a higher object than even *mechanics* and *aſtronomy*.

ed of ſtrict juſtice, and the ſteady reſolution with which he practiſed it on all occaſions, an incident which occurred between him and one of his tenants, within theſe ten years, may here be mentioned. This man falling behind hand in the payment of his rent, which was L.500 *per annum*, it was repreſented to his landlord that it was owing to his being over-rented. This being believed to be the caſe, a new valuation was made; and it was then agreed that, for the future, the rent ſhould not be more than L.450. Juſtly inferring, moreover, that if the farm was *then* too dear, it muſt neceſſarily have been *always* too dear, unaſked, and of his own accord, he immediately ſtruck off L.50 from the commencement of the leaſe; and inſtantly refunded all that he had received more than L.450 *per annum*.

Mr Parkhurſt was in his perſon rather below the middle ſize, but remarkably upright, and firm in his gait. He was all his life of a ſickly habit: and his leading ſo remarkably ſtudious and ſedentary a life (it having, for many years, been his conſtant practice to riſe at five, and, in winter, to light his own fire) to the very verge of David's limits of the life of man, is a conſolatory proof to men of ſimilar habits, how much, under many diſadvantages, may ſtill be effected by ſtrict temperance and a careful regimen. He alſo gave leſs of his time to the ordinary interruptions of life than is common. In an hoſpitable, friendly, and pleaſant neighbourhood, he viſited little; alleging, that ſuch a courſe of life neither ſuited his temper, his health, nor his ſtudies. Yet he was of ſociable manners; and his converſation always inſtructive, often delightful: for his ſtores of knowledge were ſo large, that he too has often been called a walking library. He belonged to no clubs; he frequented no public places; and there are few men who, towards the cloſe of life, may not, on a retroſpect, reflect with ſhame and ſorrow, how much of their precious time has thus been thrown away, or, perhaps, worſe than thrown away.

Like many other men of infirm and ſickly frames, Mr Parkhurſt was alſo irritable, and quick, warm, and earneſt, in his reſentments, though never unforgiving. But whether it be or be not a matter of reproach to poſſeſs a mind ſo conſtituted, it certainly is much to any man's credit to counteract and ſubdue it by an attention to the injunctions of religion. This Mr Parkhurſt effectually did: and few men have paſſed through a long life more at peace with his neighbours, more reſpected by men of learning, more beloved by his friends, or more honoured by his family.

PARKINSON (John). Of this ingenious Engliſh botaniſt, one of the firſt and moſt induſtrious cultivators of that ſcience among us, the memorials that remain are very ſcanty. He was born in 1567, was bred an apothecary, and reſided in London. He roſe to ſuch reputation in his profeſſion as to be appointed apothecary to King James I.; and, on the publication of his Theatre of Plants, he obtained from the unfortunate ſucceſſor of that prince the title of *Botanicus Regis primarius*. The time of his death cannot be exactly aſcertained; but, as his Herbal was publiſhed in 1640, and it appears that he was living at that time, he muſt have attained his 73d year. Biog. Dict.

Parkinſon's firſt publication was, his 1. *Paradiſi in Sole Paradiſus terreſtris*, or, A Garden of all Sorts of Pleaſant Flowers which our Engliſh Ayre will permit to be nurſed up: with a Kitchen-garden of all manner of Herbes, Roots, and Fruits, for Meat or Sauſe, &c. &c. Collected by John Parkinſon apothecary, of London, 1629, folio, 612 pages. In this work the plants are arranged without any exact order: nearly 1000 plants are ſeparately deſcribed, of which 780 are figured on 129 tables, which appear to have been cut expreſsly for this work. Parkinſon was, it is conceived, the firſt Engliſh author who ſeparately deſcribed and figured the ſubjects of the flower garden; and this book is therefore a valuable curioſity, as exhibiting a complete view of the extent of the Engliſh garden at the beginning of the laſt century. It may, perhaps, be neceſſary to inform the reader, that Paradiſus in Sole, is meant to expreſs the author's name, *Park in ſun*. 2. In 1640 he publiſhed his *Theatrum Botanicum*; or Theatre of Plants, or an Herbal of a large extent: containing therein, a more ample and exact Hiſtory and declaration of the Phyſical Herbs and Plants than are in other Authors, &c. &c. London, folio, 1746 pages. This work had been the labour of the author's life; and he tells us that, owing to "the diſaſtrous times," and other impediments, the printing of it was long retarded. Dr Pulteney is of opinion, that, allowing for the defects common to the age, Parkinſon will appear "more of an original author than Gerard or Johnſon, independent of the advantages he might derive from being poſterior to them. His theatre was carried on through a long ſeries of years, and he profited by the works of ſome late authors, which Johnſon, though they were equally in his power, had neglected to uſe. Parkinſon's deſcriptions, in many inſtances, appear to be new. He is more particular in pointing out the places of growth. Johnſon had deſcribed about 2850 plants, Parkinſon has near 3800. Theſe accumulations rendered the *Theatrum Botanicum* the moſt copious book on the ſubject in the Engliſh language; and it may be preſumed, that it gained equally the approbation of medical people, and of all thoſe who were curious and inquiſitive in this kind of knowledge."

PARSONS (James), an excellent phyſician and polite ſcholar, was born at Barnſtaple, in Devonſhire, in March 1705. His father, who was the youngeſt of nine ſons of Colonel Parſons, and nearly related to the baronet of that name, being appointed barrack-maſter at Bolton in Ireland, removed with his family into that kingdom ſoon after the birth of his then only ſon James, who received at Dublin the early part of his education, and, by the aſſiſtance of proper maſters, laid a conſiderable foundation of claſſical and other uſeful learning, which enabled him to become tutor to Lord Kingſton. Turning his attention to the ſtudy of medicine, he went afterwards to Paris, where (to uſe his own words) "he followed the moſt eminent profeſſors in the ſeveral ſchools, as Aſtruc, Dubois, Lemery, and others; attended the anatomical lectures of the moſt famous [Hunaud and De Cat]; and chemicals at the King's Garden at St Come. He followed the phyſicians in both hoſpitals of the Hotel Dieu and La Charité, and the chemical lectures and demonſtrations of Lemery and Bouldoc; and in botany Juſſieu. Having finiſhed theſe ſtudies, his profeſſors gave him honourable atteſtations of his having followed them with diligence: Biog. Dict.

gence and induſtry, which intitled him to take the degrees of doctor and profeſſor of the art of medicine, in any univerſity in the dominions of France. Intending to return to England, he judged it unneceſſary to take degrees in Paris, unleſs he had reſolved to reſide there; and as it was more expenſive, he therefore went to the univerſity of Rheims, in Champaign, where, by virtue of his atteſtations, he was immediately admitted to three examinations, as if he had finiſhed his ſtudies in that academy; and there was honoured with his degrees June 11. 1736, In the July following he came to London, and was ſoon employed by Dr James Douglas to aſſiſt him in his anatomical works, where in ſome time he began to practiſe. He was elected a member of the Royal Society in 1740; and, after due examination, was admitted a licentiate of the college of phyſicians April 1. 1751; paying college fees and bond ſtamps of different denominations to the amount of L.41 : 2 : 8, ſubject alſo to quarterage of L. 2 *per annum*. In 1755 he paid a farther ſum of L. 7, which, with the quarterage money already paid, made up the ſum of L. 16, in lieu of all future payments." On his arrival in London, by the recommendation of his Paris friends, he was introduced to the acquaintance of Dr Mead, Sir Hans Sloane, and Dr James Douglas. This great anatomiſt made uſe of his aſſiſtance, not only in his anatomical preparations, but alſo in his repreſentations of morbid and other appearances; a liſt of ſeveral of which was in the hands of his friend Dr Maty, who had prepared an *eloge* on Dr Parſons, which was never uſed, but which, by the favour of Mrs Parſons, Mr Nichols has preſerved at large. Though Dr Parſons cultivated the ſeveral branches of the profeſſion of phyſic, he was principally employed in the obſtetrical line. In 1738, by the intereſt of his friend Dr Douglas, he was appointed phyſician to the public infirmary in St Giles's. In 1739 he married Miſs Elizabeth Reynolds, by whom he had two ſons and a daughter, who all died young. Dr Parſons reſided for many years in Red Lion Square, where he frequently enjoyed the company and converſation of Dr Stukely, Biſhop Lyttleton, Mr Henry Baker, Dr Knight, and many other of the moſt diſtinguiſhed members of the Royal and Antiquarian Societies, and that of Arts, Manufactures, and Commerce; giving weekly an elegant dinner to a large but ſelect party. He enjoyed alſo the literary correſpondence of D'Argenville, Buffon, Le Cat, Beccaria, Amb. Bertrand, Valltravers, Aſcanius, Turberville Needham, Dr Garden, and others of the moſt diſtinguiſhed rank in ſcience. As a practitioner, he was judicious, careful, honeſt, and remarkably humane to the poor; as a friend, obliging and communicative; chearful and decent in converſation, ſevere and ſtrict in his morals, and attentive to fill with propriety all the various duties of life. In 1769, finding his health impaired, he propoſed to retire from buſineſs and from London; and with that view diſpoſed of a conſiderable number of his books and foſſils, and went to Briſtol. But he returned ſoon after to his old houſe, and died in it after a week's illneſs, on the 4th of April, 1770. By his laſt will, dated in October 1766, he gave his whole property to Mrs Parſons; and in caſe of her death before him, to Miſs Mary Reynolds her only ſiſter, "in recompence for her affectionate attention to him and to his wife, for a long courſe of years, in ſickneſs and in health." It was his particular requeſt, that he ſhould not be buried till ſome change ſhould appear in his corpſe; a requeſt which occaſioned him to be kept unburied 17 days, and even then ſcarce the ſlighteſt alteration was perceivable. He was buried at Hendon, in a vault which he had cauſed to be built on the ground purchaſed on the death of his ſon James, where his tomb had a very commendatory inſcription.

It would carry us beyond our uſual limits to enter into an enumeration of the many curious articles at various times communicated to the public by Dr Parſons, which may be ſeen in the Anecdotes of Bowyer. We ſhall therefore cloſe this article with an extract from Dr Maty's eulogium: "The ſurpriſing variety of branches which Dr Parſons embraced, and the ſeveral living as well as dead languages he had a knowledge of, qualified him abundantly for the place of aſſiſtant ſecretary for foreign correſpondences, which the council of the Royal Society beſtowed upon him about the year 1750. He acquitted himſelf to the utmoſt of his power of the functions of this place, till a few years before his death, when he reſigned in favour of his friend, who now gratefully pays this laſt tribute to his memory. Dr Parſons joined to his academical honours thoſe which the Royal College of Phyſicians of London beſtowed upon him, by admitting him, after due examination, licentiate, on the firſt day of April 1751. The diffuſive ſpirit of our friend was only equalled by his deſire of information. To both theſe principles he owed the intimacies which he formed with ſome of the greateſt men of his time. The names of Folkes, Hales, Mead, Stukely, Needham, Baker, Collinſon, and Garden, may be mentioned on this occaſion, and many more might be added. Weekly meetings were formed, where the earlieſt intelligence was received and communicated of any diſcovery both here and abroad; and new trials were made, to bring to the teſt of experience the reality or uſefulneſs of theſe diſcoveries. Here it was that the microſcopical animals found in ſeveral infuſions were firſt produced; the propagation of ſeveral inſects by ſection aſcertained; the conſtancy of Nature amidſt theſe wonderful changes eſtabliſhed. His Remains of Japhet, being Hiſtorical Enquiries into the Affinity and Origin of the European Languages, are a moſt laborious performance, tending to prove the antiquity of the firſt inhabitants of theſe iſlands as being originally deſcended from Gomer and Magog, above 1000 years before Chriſt, their primitive and ſtill ſubſiſting language, and its affinity with ſome others. It cannot be denied but that there is much ingenuity, as well as true learning, in this work, which helps conviction, and often ſupplies the want of it. But we cannot help thinking that our friend's warm feelings now and then miſlead his judgment, and that ſome at leaſt of his conjectures, reſting upon partial traditions, and poetical ſcraps of Iriſh filids and Welſh bards, are leſs ſatisfactory than his tables of affinity between the ſeveral northern languages, as deduced from one common ſtock. Literature, however, is much obliged to him for having in this, as well as in many of his other works, opened a new field of obſervations and diſcoveries. In enumerating our learned friend's diſſertations, we find ourſelves at a loſs whether we ſhould follow the order of ſubjects or of time; neither is it eaſy to account for their ſurpriſing variety and quick ſucceſſion. The truth is, that his eagerneſs after knowledge was ſuch, as to embrace almoſt with equal facility all its branches, and with equal zeal to aſcertain the merit of inventions, and aſcribe to their reſpective, and ſometimes unknown, authors, the glory of the diſcovery. Many operations, which the ancients have tranſmitted to us, have been thought fabulous, merely from our ignorance of the art by which they were performed. Thus the burning of the ſhips of the Romans at a conſiderable diſtance, during the ſiege of Syracuſe, by Archimedes, would perhaps ſtill continue to be exploded, had not the celebrated M. Buffon in France ſhewn the poſſibility of it, by preſenting and deſcribing a model of a ſpeculum, or rather aſſemblage of mirrors, by which he could ſet fire at the diſtance of ſeveral hundred feet. In the contriving, indeed, though not in the executing of ſuch an apparatus, he had in ſome meaſure been foreſtalled by a writer now very little known or read. This Dr Parſons proved in a very ſatisfactory manner; and he had the pleaſure to find the French philoſopher did not refuſe to the Jeſuit his ſhare in the invention, and was not at all offended by the liberty he had taken. Another French diſcovery, I mean a new kind of painting fathered upon the ancients, was reduced to its real value, in a paper which ſhewed our author was poſſeſſed of a good taſte for the fine arts: and I am informed that his ſkill in muſic was by no means inferior, and that his favourite amuſement was the flute. Richly, it appears from theſe performances, did our author merit the honour of being a member of the Antiquarian Society, which long ago had aſſociated him to its labours. To another ſociety, founded upon the great principles of humanity, patriotiſm, and natural emulation, he undoubtedly was greatly uſeful (A). He aſſiſted at moſt of their general meetings and committees, and was for many years chairman to that of agriculture; always equally ready to point out and to promote uſeful improvements, and to oppoſe the intereſted views of fraud and ignorance, ſo inſeparable from very extenſive aſſociations. No ſooner was *this* ſociety (B) formed, than Dr Parſons became a member of it. Intimately convinced of the nobleneſs of its views, though from his ſtation in life little concerned in its ſucceſs, he grudged neither attendance nor expence. Neither ambitious of taking the lead, nor fond of oppoſition, he joined in any meaſure he thought right; and ſubmitted cheerfully to the ſentiments of the majority, though againſt his own private opinion. The juſt ideas he had of the dignity of our profeſſion, as well as of the common links which ought to unite all its members, notwithſtanding the differences of country, religion, or places of education, made him bear impatiently the ſhackles laid upon a great number of reſpectable practitioners: he wiſhed, fondly wiſhed, to ſee theſe broken; not with a view of empty honour and dangerous power, but as the only means of ſerving mankind more effectually, checking the progreſs of deſigning men and illiterate practitioners, and diffuſing through the whole body a ſpirit of emulation. Though by frequent diſappointments he foreſaw, as well as we, the little chance of a ſpeedy redreſs, he nobly perſiſted in the attempt; and had he lived to the final event, would undoubtedly, like Cato, ſtill have preferred the conquered cauſe to that ſupported by the gods. After having tried to retire from buſineſs and from London, for the ſake of his health, and having diſpoſed of moſt of his books with that view, he found it inconſiſtent with his happineſs to forſake all the advantages which a long reſidence in the capital, and the many connections he had formed, had rendered habitual to him. He therefore returned to his old houſe, and died in it, after a ſhort illneſs, April 4. 1770. The ſtyle of our friend's compoſition was ſufficiently clear in deſcription, tho' in argument not ſo cloſe as could have been wiſhed. Full of his ideas, he did not always ſo diſpoſe and connect them together, as to produce in the minds of his readers that conviction which was in his own. He too much deſpiſed thoſe additional graces which command attention when joined to learning, obſervation, and ſound reaſoning. Let us hope that his example and ſpirit will animate all his colleagues; and that thoſe practitioners who are in the ſame circumſtances will be induced to join their brethren, ſure to find amongſt them thoſe great bleſſings of life, freedom, equality, information, and friendſhip. As long as theſe great principles ſhall ſubſiſt in this ſociety, and I truſt they will outlaſt the longeſt liver, there is no doubt but the members will meet with the reward honeſt men are ambitious of, the approbation of their conſcience, the eſteem of the virtuous, the remembrance of poſterity."

PARODICAL DEGREES, in an equation, a term that has been ſometimes uſed to denote the ſeveral regular terms in a quadratic, cubic, biquadratic, &c. equation, when the indices of the powers aſcend or deſcend orderly in an arithmetical progreſſion. Thus, $x^3 + mx^2 + nx = p$ is a cubic equation where no term is wanting, but having all its parodic degrees; the indices of the terms regularly deſcending thus, 3, 2, 1, 0.

PARTY ARCHES, in architecture, are arches built between ſeparate tenures, where the property is intermixed, and apartments over each other do not belong to the ſame eſtate.

Party Walls, are partitions of brick made between buildings in ſeparate occupations, for preventing the ſpread of fire. Theſe are made thicker than the external walls; and their thickneſs in London is regulated by act of Parliament of the 14th of George III.

PASSIGRAPHY, the art of writing on any ſubject ſo as to be underſtood by all nations (See *Univerſal Characters* in this *Supplement*). In France, where every thing is admired that is new, and every vagary of the imagination of a pretended philoſopher thought practicable, a propoſal has lately been made to introduce one univerſal language into the world, conſtructed by a few metaphyſicians on the laws of human thought. And to this language, in its written form, is to be given the name of *paſſigraphy*. Such readers as think this idle dream

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(A) The Society for the Encouragement of Arts, Manufactures, and Commerce. He likewiſe was aſſociated to the Economical Society at Berne, Dec. 26. 1763.

(c) A Medical Society inſtituted by Dr Fothergill, and other reſpectable phyſicians, licentiates, in vindication of their privileges; where, it ſhould ſeem, this eulogy was intended to be pronounced.

dream worthy their attention (which is far from being the caſe with us), will find ſome ingenious thoughts on the hiſtory of a philoſophical language, in the 2d volume of *Nicholſon's Journal of Natural Philoſophy, &c.*

PATH OF THE VERTEX, a term frequently uſed by Mr Flamſteed, in his Doctrine of the Sphere, denoting a circle, deſcribed by any point of the earth's ſurface as the earth turns round its axis. This point is conſidered as vertical to the earth's centre; and is the ſame with what is called the vertex or zenith in the Ptolomaic projection.

PEARL FISH, is commonly conſidered as an *aſcidia* (ſee MYTILUS, *Encycl.*); but this is denied by a late author, who ſeems to have paid great attention to the pearl-fiſhery at Ceylon. It has never, he ſays, been accurately deſcribed. It does not reſemble the *aſcidia* of Linnæus; and as he thinks it may form a new genus, he gives the following account of it:

"The fiſh is faſtened to the upper and lower ſhells by two white flat pieces of muſcular ſubſtance, which have been called ears, and extend about two inches from the thick part of the body, growing gradually thinner. The extremity of each ear lies looſe, and is ſurrounded by a double brown fringed line. Theſe lie almoſt the third part of an inch from the outer part of the ſhell, and are continually moved by the animal. Next to theſe, above and below, are ſituated two other double fringed moveable ſubſtances, like the bronchiæ of a fiſh. Theſe ears and fringes are joined to a cylindrical piece of fleſh of the ſize of a man's thumb, which is harder and of a more muſcular nature than the reſt of the body. It lies about the centre of the ſhells, and is firmly attached to the middle of each. This, in fact, is that part of the pearl-fiſh which ſerves to open and ſhut the ſhells. Where this column is faſtened, we find on the fleſh deep impreſſions, and on the ſhell various nodes of round or oblong forms, like imperfect pearls. Between this part and the hinge (*cardo*) lies the principal body of the animal, ſeparated from the reſt, and ſhaped like a bag. The mouth is near the hinge of the ſhell, enveloped in a veil, and has a double flap or lip on each ſide; from thence we obſerve the throat (*æſophagus*) deſcending like a thread to the ſtomach. Cloſe to the mouth there is a curved browniſh tongue, half an inch in length, with an obtuſe point; on the concave ſide of this deſcends a furrow, which the animal opens and ſhuts, and probably uſes to convey food to its mouth. Near its middle are two bluiſh ſpots, which ſeem to be the eyes. In a pretty deep hole, near the baſe of the tongue, lies the beard (*byſſus*), faſtened by two fleſhy roots, and conſiſting of almoſt 100 fibres, each an inch long, of a dark green colour, with a metallic luſtre; they are undivided, parallel, and flattened. In general, the *byſſus* is more than three quarters of an inch without the cleft (*rima*); but if the animal is diſturbed, it contracts it conſiderably. The top of each of theſe threads terminates in a circular gland or head, like the *ſtigma* of many plants. With this *byſſus* they faſten themſelves to rocks, corals, and other ſolid bodies; by it the young pearl-fiſh cling to the old ones, and with it the animal procures its food, by extending and contracting it at pleaſure. Small ſhell fiſh, on which they partly live, are often found clinging to the former. The ſtomach lies cloſe to the root of the beard, and has, on its lower ſide, a protracted obtuſe point. Above the ſtomach are two ſmall red bodies, like lungs; and from the ſtomach goes a long channel or gut, which takes a circuit round the muſcular column above-mentioned, and ends in the anus, which lies oppoſite to the mouth, and is covered with a ſmall thin leaf, like a flap. Though the natives pretend to diſtinguiſh the ſexes by the appearance of the ſhell, calling the flat ones males, and thoſe which are thick, concave, and vaulted, females, our author, on a cloſe inſpection, could not perceive any viſible ſexual difference."

The pearls are only in the ſofter part of the animal, and never in the firm muſcular column above-mentioned. They are found, in general, near the earth, and on both ſides of the mouth. From the appearance of the ſhell a judgment may be formed, with greater or leſs probability, whether it contains pearls or not. Thoſe which have a thick calcareous cruſt upon them, to which *ſerpulæ* (ſea tubes) *Tubuli marini irregulariter intorti, Criſta-gali Chamar lazuras, Lepas tintinabulum, Madreporee, Millipore, Cellipore, Gorgontæ, Spongiæ*, and other Zoophytes, are faſtened, have arrived at their full growth, and commonly contain the beſt pearls; but thoſe that appear ſmooth, contain either none, or ſmall ones only.

In the article (*Encycl.*) intitled, *Manner of Fiſhing for* PEARLS *in the Eaſt Indies*, we have moſt unaccountably ſaid, that "the beſt divers will keep under water near *half an hour*, and the reſt not leſs than a quarter!" This is a very great miſtake; for M. *Le Beck* aſſures us, that the time during which a diver is able to remain under water ſeldom exceeds two minutes; and that, even after that ſhort period, he diſcharges, on emerging from the ſea, a quantity of water, and ſometimes a little blood, from his mouth and noſe. We have mentioned the danger which the divers run of becoming a prey to monſtrous fiſhes. Theſe fiſhes are ſharks; of which ſuch a dread is juſtly entertained, that the moſt expert divers will not, on any account, deſcend, till the conjurer has performed his ceremonies of inchantment. Theſe conſiſt in a number of prayers, learned by heart, that nobody, probably not even the conjurer himſelf, underſtands, which he, ſtanding on the ſhore, continues muttering and grumbling from ſun riſe until the boats return. During this period, he is obliged to abſtain from food and ſleep, otherwiſe his prayers would have no avail: he is, however, allowed to drink; which privilege he indulges in a high degree, and is frequently ſo giddy, as to be rendered very unfit for devotion. Some of the conjurers accompany the divers in their boats; which pleaſes them very much, as they have their protectors near at hand.

PEDOMETER (ſee *Encycl.*), is the name given by Mr Lewin Thugwell to an inſtrument, which is rather an improved PERAMBULATOR than the inſtrument which we have noticed by the name of Pedometer. The chief improvement made by him on the PERAMBULATOR (ſee that article, *Encycl.*) is in the ſize of the wheel, of which the circumference meaſures 16½ feet, or one pole, adapted to Gunter's conciſe method of arithmetic, and divided into 25 equal parts, correſponding to the links of his chain for land meaſuring. There is likewiſe a contrivance in Mr Thugwell's pedometer, for compelling the attention of the traveller to the inſtrument at the end of every mile. It is very ingenious, and abundantly ſimple; but we hardly think it of ſufficient

cient importance to fill the ſpace which a complete deſcription of it would occupy in this Work. It is fully deſcribed in the *Letters and Papers of the Bath and Weſt of England Society, for the Encouragement of Agriculture;* and likewiſe in the 6th volume of the *Repertory of Arts and Manufactures.*

PEGUE, the ancient capital of the kingdom of the ſame name (ſee Pegu, *Encycl.*), appears to have been a quadrangle, each ſide meaſuring about a mile and a half. It was ſurrounded by a ditch and wall; which, before the latter tumbled down, and the former was filled up, muſt have furniſhed no contemptible defence. The breadth of the ditch appears to be about 60 yards; its depth, where not choked up, about ten or twelve feet; and there is ſtill in it water enough to impede an eaſtern ſiege. The wall has been at leaſt 25 feet high, and its breadth at the baſe not leſs than 40. It is compoſed of brick, badly cemented together with clay mortar, and has had on it ſmall equidiſtant baſtions, about 300 yards aſunder.

Nothing can exhibit a more ſtriking picture of deſolation than the inſide of this wall. We have elſewhere given an account of the almoſt inceſſant wars between the kings of Pegue and Birma or Barma. In the year 1757, the Birman ſovereign carried the city of Pegue by aſſault, razed every dwelling to the ground, and diſperſed, or led into captivity, all the inhabitants. The pagodas, which are very numerous, were the only buildings that eſcaped the fury of the conqueror; and of theſe the great pagoda of Shoemadoo has alone been attended to, and repaired.

This extraordinary edifice is built on a double terrace, one raiſed upon another. The lower and greater terrace is about ten feet above the natural level of the ground. It is quadrangular. The upper and leſſer terrace is of a like ſhape, raiſed about 20 feet above the lower terrace, or 30 above the level of the country. Theſe terraces are aſcended by flights of ſtone ſteps, broken and neglected. On each ſide are dwellings of the *Rahaans* or prieſts, raiſed on timbers four or five feet from the ground. Their houſes conſiſt only of a ſingle hall. The wooden pillars that ſupport them are turned with neatneſs. The roof is of tile, and the ſides of ſheathing-boards. There are a number of bare benches in every houſe, on which the *Rahaans* ſleep. They appear to have no furniture.

Shoemadoo is a pyramid, compoſed of brick and plaſter, with fine ſhell mortar, without excavation or aperture of any ſort; octagonal at the baſe, and ſpiral at the top. Six feet from the ground there is a wide ledge, which ſurrounds the baſe of the building; on the plane of which are 57 ſmall ſpires, of equal ſize, and equidiſtant. One of them meaſured 27 feet in height, and 40 in circumference at the bottom. On a higher ledge there is another row, conſiſting of 53 ſpires, of ſimilar ſhape and meaſurement. A great variety of mouldings encircles the building; and ornaments, ſomewhat reſembling the *fleur de lys*, ſurround what may be called the baſe of the ſpire. Circular mouldings likewiſe gird this part to a conſiderable height; above which there are ornaments in ſtucco, not unlike the leaves of a Corinthian capital; and the whole is crowned by a *tee*, or umbrella of open iron-work, from which riſes an iron rod with a gilded penant.

The extreme height of the building, from the level of the country, is 361 feet; and above the interior terrace, 331 feet. On the ſouth-eaſt angle of the upper terrace there are two handſome ſaloons, or *keouns*, lately erected. The roof is compoſed of different ſtages, ſupported by pillars. Captain Symes, from whoſe memoir in the Aſiatic Reſearches this account is taken, judged the length of each ſaloon to be about 60 feet, and the breadth 30. The ceiling of one of them was already embelliſhed with gold leaf, and the pillars lacquered; the other, when he ſaw it, was not completed. They are made entirely of wood. The carving on the outſide is very curious. He ſaw ſeveral unfiniſhed figures, intended to be fixed on different parts of the building; ſome of them not ill ſhapen, and many exceedingly groteſque. Splendid images of Gaudma (the *Birman* object of adoration) were preparing, which he underſtood were deſigned to occupy the inſide of theſe *keouns*.

At each angle of the interior terrace is a pyramidical pagoda, 67 feet in height, reſembling, in miniature, the great pagoda. In front of the one in the ſouth-weſt corner are four gigantic repreſentations in maſonry of Palloo, or the *man-deſtroyer*, half beaſt, half human, ſeated on their hams, each with a large club on the right ſhoulder.

Nearly in the centre of the eaſt face of the area are two human figures in ſtucco beneath a gilded umbrella. One ſtanding, repreſents a man with a book before him, and a pen in his hand. He is called *Thagiamee*, the recorder of mortal merits and mortal miſdeeds. The other, a female figure kneeling, is *Maha Sumdere*, the protectreſs of the univerſe, as long as the univerſe is doomed to laſt: but when the time of general diſſolution arrives, by her hand the world is to be overwhelmed, and deſtroyed everlaſtingly.

On the north ſide of the great pagoda are three large bells, of good workmanſhip, ſuſpended near the ground between pillars. Several deers horns are ſtrewed around. Thoſe who come to pay their devotions firſt take up one of the horns, and ſtrike the bell three times, giving an alternate ſtroke to the ground. This act is to announce to the ſpirit of Gaudma the approach of a ſuppliant. There are ſeveral low benches near the bottom of the pagoda, on which the perſon who comes to pray places his offering; which generally conſiſts of boiled rice, a plate of ſweetmeats, or cocoa-nut fried in oil. When it is given, the devotee cares not what becomes of it. The crows and dogs commonly eat it up in the preſence of the donor, who never attempts to prevent or moleſt the animals.

There are many ſmall pagodas on the areas of both terraces, which are neglected, and ſuffered to fall into decay. Numberleſs images of Gaudma lie indiſcriminately ſcattered. A pious Birman who purchaſes an idol, firſt procures the ceremony of conſecration to be performed by the *Rahaans*, then takes his purchaſe to whatever ſacred building is moſt convenient, and there places it either in the ſhelter of a *keoun*, or on the open ground before the temple: nor does he ever after ſeem to have any anxiety about its preſervation, but leaves the divinity to ſhift for itſelf.

From the upper ledge that ſurrounds the baſe of Shoemadoo, the proſpect of the country is extenſive and pictureſque; but it is a proſpect of Nature in her rudeſt ſtate. There are few inhabitants, and ſcarcely any cultivation. The hills of *Martaban* riſe to the eaſtward; and the *Sitang* river, winding along the plains, gives here and there an interrupted view of its waters. To the north-north-weſt, above 40 miles, are the *Galladzet* hills, whence the Pegue river takes its riſe; hills remarkable only for the noiſome effects of their atmoſphere. In every other direction the eye looks over a boundleſs plain, chequered by a wild intermixture of wood and water.

The preſent king of the Birmans has entirely altered the ſyſtem of his predeceſſors. He has turned his attention to the population and improvement, rather than the extenſion, of his dominions; and ſeems more deſirous to conciliate his new ſubjects by mildneſs, than to rule them through terror. He has abrogated ſeveral ſevere penal laws impoſed upon the *Taliens* or Peguers: juſtice is now diſtributed impartially; and the only diſtinction at preſent between a Birman and Talien conſiſts in the excluſion of the latter from all public offices of truſt and power.

No act of the Birman government is more likely to reconcile the Taliens to the Birman yoke than the reſtoration of their ancient place of abode, and the preſervation and embelliſhment of the pagoda of Shoemadoo. So ſenſible was the king of this, as well as of the advantages that muſt accrue to the ſtate from an increaſe of culture and population, that ſome years ago he iſſued orders to rebuild Pegue, encouraged new ſettlers by liberal grants, and invited the ſcattered families of former inhabitants to return and repeople their deſerted city.

Pegue, in its renovated ſtate, ſeems to be built on the plan of the former city. It is a ſquare, each ſide meaſuring about half a mile. It is fenced round by a ſtockade, from 10 to 12 feet high. There is one main ſtreet running eaſt and weſt, which is interſected at right angles by two ſmaller ſtreets, not yet finiſhed. At each extremity of the principal ſtreet there is a gate in the ſtockade, which is ſhut early in the evening. After that hour, entrance during the night is confined to a wicket. Each of theſe gates is defended by a ſorry piece of ordnance, and a few muſqueteers, who never poſt centinels, and are uſually aſleep. There are alſo two other gates on the north and ſouth ſides of the ſtockade.

The houſes of the inhabitants of Pegue are far from commodious, agreeably to European notions of accommodation; but they are at leaſt as much ſo as the houſes of other Indian towns. There are no brick buildings in Pegue, except ſuch as belong to the king, or are dedicated to Gaudma. The king has prohibited the uſe of brick or ſtone in private buildings, from the apprehenſion, that if people got leave to build brick houſes, they might erect brick fortifications, dangerous to the ſecurity of the ſtate. The houſes, therefore, are all made of mats or ſheathing-boards, ſupported on bamboos or poſts. Being compoſed of ſuch combuſtible materials, the inhabitants are under continual dread of fire, againſt which they take every precaution. The roofs are lightly covered; and at each door ſtands a long bamboo, with a hook at the end, to pull down the thatch: alſo another pole, with a grating of ſplit bamboo at the extremity, about three feet ſquare, to ſuppreſs flame by preſſure. Almoſt every houſe has earthen pots of water on the roof. And there is a particular claſs of people, whoſe buſineſs it is to prevent and extinguiſh fires.

PEISHCAR, in Bengal, principal in office.

PEISHCUSH, a fine, tribute, or preſent.

PELL (Dr John), an eminent Engliſh mathematician, deſcended from an ancient family in Lincolnſhire, was born at Southwick in Suſſex, March 1. 1610, where his father was miniſter. He received his grammar education at the free-ſchool at Stenning in that county. At the age of 13 he was ſent to Trinity college in Cambridge, being then as good a ſcholar as moſt maſters of arts in that univerſity; but though he was eminently ſkilled in the Greek and Hebrew languages, he never offered himſelf a candidate at the election of ſcholars or fellows of his college. His perſon was handſome; and being of a ſtrong conſtitution, uſing little or no recreations, he proſecuted his ſtudies with the more application and intenſeneſs.

In 1629 he drew up the "Deſcription and Uſe of the Quadrant, written for the Uſe of a Friend," in two books; the original manuſcript of which is ſtill extant among his papers in the Royal Society. And the ſame year he held a correſpondence with Mr Briggs on the ſubject of logarithms.

In 1630, he wrote *Modus ſupputandi Ephemerides Aſtronomicas, &c. ad an.* 1630 *accommodatus*; and, A Key to unlock the meaning of Johannes Trithemius, in his Diſcourſe on Steganography: which Key he imparted to Mr Samuel Hartlib and Mr Jacob Homedæ. The ſame year he took the degree of Maſter of Arts at Cambridge. And the year following he was incorporated in the univerſity of Oxford. June the 7th, he wrote A Letter to Mr Edmond Wingate on Logarithms: and, Oct. 5. 1631, *Commentationes in Coſmographiam Alſtedii.*

In 1632 he married Ithamaria, ſecond daughter of Mr Henry Reginolles of London, by whom he had four ſons and four daughters.—March 6. 1634, he finiſhed his "Aſtronomical Hiſtory of Obſervations of Heavenly Motions and Appearances;" and April the 10th, his *Ecliptica Prognoſtica*, or Foreknower of the Eclipſes, &c. In 1634 he tranſlated "The Everlaſting Tables of Heavenly Motions," grounded upon the Obſervations of all Times, and agreeing with them all, by Philip Lanſberg, of Ghent in Flanders. And June the 12th, the ſame year, he committed to writing "The Manner of Deducing his Aſtronomical Tables out of the Tables and Axioms of Philip Lanſberg."—March the 9th, 1625, he wrote "A Letter of Remarks on Gellibrand's Mathematical Diſcourſe on the Variation of the Magnetic Needle." And the 3d of Juue following, another on the ſame ſubject.

His eminence in mathematical knowledge was now ſo great, that he was thought worthy of a Profeſſor's chair in that ſcience; and, upon the vacancy of one at Amſterdam in 1639, Sir William Boſwell, the Engliſh Reſident with the States General, uſed his intereſt, that he might ſucceed in that Profeſſorſhip. It was not filled up, however, till 1642, when Pell was choſen to it; and he read with great applauſe public lectures upon Diophantus.—In 1644 he printed at Amſterdam, in two pages 4to, "A Refutation of Longomontanus's Diſcourſe," *De Vera Circuli Menſura.*

Pell.

In 1646, on the invitation of the Prince of Orange, he removed to the new college at Breda, as Profeſſor of Mathematics, with a ſalary of 1000 guilders a year. His *Idea Matheſeos*, which he had addreſſed to Mr Hartlib, who in 1639 had ſent it to Des Cartes and Merſenne, was printed 1650 at London, in 12mo, in Engliſh, with the title of *An Idea of Mathematics*, at the end of Mr John Durie's Reformed Library-keeper. It is alſo printed by Mr Hook, in his Philoſophical Collections, N° 5. p. 127.; and is eſteemed our author's principal work.

In 1652 Pell returned to England; and in 1654 he was ſent by the protector Cromwell agent to the Proteſtant Cantons in Switzerland; where he continued till June 23. 1658, when he ſet out for England, where he arrived about the time of Cromwell's death. His negociations abroad gave afterwards a general ſatisfaction, as it appeared he had done no ſmall ſervice to the intereſt of King Charles II. and of the church of England; ſo that he was encouraged to enter into holy orders: and in the year 1661 he was inſtituted to the rectory of Fobbing in Eſſex, given him by the king. In December that year, he brought into the upper houſe of convocation the calendar reformed by him, aſſiſted by Sancroft, afterwards archbiſhop of Canterbury. In 1673 he was preſented by Sheldon, biſhop of London, to the rectory of Laingdon in Eſſex; and, upon the promotion of that biſhop to the ſee of Canterbury ſoon after, became one of his domeſtic chaplains. He was then doctor of divinity, and expected to be made a dean; but his improvement in the philoſophical and mathematical ſciences was ſo much the bent of his genius, that he did not much purſue his private advantage. The truth is, he was a helpleſs man, as to worldly affairs; and his tenants and relations impoſed upon him, cozened him of the profits of his parſonage, and kept him ſo indigent, that he wanted neceſſaries, even ink and paper, to his dying day. He was for ſome time confined to the King's-bench priſon for debt; but, in March 1682, was invited by Dr Whitler to live in the college of phyſicians. Here he continued till June following; when he was obliged, by his ill ſtate of health, to remove to the houſe of a grandchild of his in St Margaret's church-yard, Weſtminſter. But he died at the houſe of Mr Cothorne, reader of the church of St Giles's in the Fields, December the 12th, 1685, in the 74th year of his age, and was interred at the expence of Dr Buſby, maſter of Weſtminſter ſchool, and Mr Sharp, rector of St Giles's, in the rector's vault under that church.—Dr Pell publiſhed ſome other things not yet mentioned; a liſt of which is as follows, *viz.*

1. An Exercitation concerning Eaſter; 1644, in 4to. 2. A Table of 10,000 ſquare numbers, &c.; 1672, folio. 3. An Inaugural Oration at his entering upon the Profeſſorſhip at Breda. 4. He made great alterations and additions to Rhonius's Algebra, printed at London 1668, 4to, under the title of An Introduction to Algebra, tranſlated out of the High Dutch into Engliſh by Thomas Branker, much altered and augmented by D. P. (Dr Pell). Alſo a Table of Odd Numbers, leſs than 100,000, ſhewing thoſe that are incompoſite, &c. ſupputated by the ſame Thomas Branker. 5. His Controverſy with Longomontanus concerning the Quadrature of the Circle; Amſterdam, 1646, 4to.

Pell.
Pelletier.

He likewiſe wrote a Demonſtration of the 2d and 10th books of Euclid; which piece was in MS. in the library of Lord Brereton in Cheſhire: as alſo Archimedes's Arenarius, and the greateſt part of Diophantus's ſix books of Arithmetic; of which author he was preparing, Auguſt 1644, a new edition, in which he intended to correct the tranſlation, and make new illuſtrations. He [illegible]ſigned likewiſe to publiſh an edition of Apollonius; but laid it aſide, in May 1645, at the deſire of Golius, who was engaged in an edition of that author from an Arabic manuſcript, given him at Aleppo 18 years before. Letters of Dr Pell to Sir Charles Cavendiſh, in the Royal Society.

Some of his manuſcripts he left at Brereton in Cheſhire, where he reſided ſome years, being the ſeat of William Lord Brereton, who had been his pupil at Breda. A great many others came into the hands of Dr Buſby; which Mr Hook was deſired to uſe his endeavours to obtain for the Society. But they continued buried under duſt, and mixed with the papers and pamphlets of Dr Buſby, in four large boxes, till 1755; when Dr Birch, ſecretary to the Royal Society, procured them for that body, from the truſtees of Dr Buſby. The collection contains, not only Pell's mathematical papers, letters to him, and copies of thoſe from him, &c. but alſo ſeveral manuſcripts of Walter Warner, the mathematician and philoſopher, who lived in the reigns of James I. and Charles I.

Dr Pell invented the method of ranging the ſeveral ſteps of an algebraical calculus, in a proper order, in ſo many diſtinct lines, with the number affixed to each ſtep, and a ſhort deſcription of the operation or proceſs in the line. He alſo invented the character ÷ for diviſion, ● for involution, ɯ for evolution *.

PELLETIER (Bertrand), was born at Bayonne in 1761, and very ſoon began to diſplay an inſatiable thirſt of ſcience. It frequently happens, however, that young men, ſincerely deſirous of inſtruction, have no means or place where they can be aſſiſted in the developement of their natural talents, no maſter who may point out the direct road to ſcience, and that order and method, without which the efforts of the individual too often lead him from the object of his purſuit, inſtead of bringing him nearer to it. This was not the caſe with young Pelletier. He found every advantage in his father's houſe, where he received the firſt elements of the art of which he was afterwards the ornament; and his ſubſequent progreſs was made under Darcet, who having remarked in him that ſagacity which may be called the inſtinct of ſcience, admitted him among the pupils attached to the chemical laboratory of the college of France. Five years of conſtant application and ſtudy under ſuch a maſter, who was himſelf formed by nature, perfected by experience, and affectionately diſpoſed towards his pupil, afforded this young man a ſtock of knowledge very unuſual at his age. He ſoon gave a convincing proof of this, by publiſhing, at the age of 21, a ſet of very excellent obſervations on the arſenical acid. Macquer, by mixing nitre with the oxyd of arſenic, had diſcovered in the reſidue of this operation a ſalt ſoluble in water, ſuſceptible of cryſtallization in tetrahedral priſms, which he denominated the neutral arſenical ſalt. It is the arſeniat of potaſh. He was of opinion that no acid could decompoſe it; but Pelletier ſhewed, that the ſulphuric acid diſtilled from it does diſengage the acid of arſenic. He ſhewed the true cauſe why the neutral arſenical ſalt is not decompoſable in cloſed veſſels; and particularly the order of affinity by which the ſalt itſelf is formed in the diſtillation of the nitrate of potaſh, and the white oxyd of arſenic. He explains in what reſpects this ſalt differs from what Macquer called the liver of arſenic. Pelletier had been anticipated in this work by Scheele, by Bergman, by the academicians of Dijon, and by Berthollet; but he poſſeſſed at leaſt the merit, in the firſt eſſay of his powers, of having clearly developed all the phenomena of this operation, by retaining and even determining the quantity of gas it was capable of affording. After the ſame principles it was that he decompoſed the arſenico-ammoniacal ſalt, by ſhewing how, in the decompoſition of this laſt, the pure arſenical acid is obtained in the form of a deliqueſcent glaſs. In this work we may obſerve the ſagacity with which he was enabled to develope all the phenomena of theſe compoſitions and decompoſitions, by tracing thoſe delicate threads of ſcientific relation which connect the ſeries of facts, and are imperceptible to ordinary minds.

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* *Hutton's Mathematical Dictionary.*

Encouraged by the ſucceſs of theſe firſt works, which he preſented with the ſenſibility of grateful attachment to his inſtructor, he communicated his obſervations on the cryſtallization of ſulphur, cinnabar, and the deliqueſcent ſalts; the examination of zeolites, particularly the falſe zeolite of Fribourg in Briſgaw, which he found to be merely an ore of zinc; obſervations on the dephlogiſticated or oxygenated muriatic acid, relative to the abſorption of oxygen; on the formation of ethers, particularly the muriatic and the acetous; and ſeveral memoirs on the operation of phoſphorus made in the large way; its converſion into phoſphoric acid, and its combination with ſulphur and moſt metallic ſubſtances.

It was by his operations on that moſt aſtoniſhing production of chemiſtry, phoſphorus, that he burned himſelf ſo dangerouſly as nearly to have loſt his life. After the cure of his wound, which confined him to his bed for ſix months, he immediately began the analyſis of the various plumbagos of France, England, Germany, Spain, and America, and found means to give novelty and intereſt to his work, even after the publication of Scheele on the ſame object. The analyſis of the carbonat of barytes led him to make experiments on animals; which prove that this earth is a true poiſon, whether it be adminiſtered in the form of the native carbonat of barytes, or whether it be taken from the decompoſition of the ſulphat, even though again combined with another acid.

Chemiſts have given the name of *ſtrontian* to a newly diſcovered earth, from the name of the place where it was firſt found. Pelletier analyſed it, and diſcovered it in the ſulphat of barytes. He likewiſe analyſed the verditer of England, of which painters and paper-hangers make ſo much uſe. He diſcovered a proceſs for preparing it in the large way, by treating with lime the precipitate obtained from the decompoſition of nitrat of copper by lime. By his proceſs, verditer is afforded equal in beauty to that which comes from England. He was likewiſe one of the firſt chemiſts who ſhewed the poſſibility of refining bell metal, and ſeparating the tin. His firſt experiments were made at Paris; after which he repaired to the foundry at Romilly, to verify them in the large way. The following year he was received a member of the Academy of Sciences at Paris, and ſhortly afterwards went to La Fere, with Borda and General Daboville, to aſſiſt in experiments upon a new gunpowder. Being obliged, in order to render his experiments more deciſive, to paſs great part of the day in the open air during a cold and humid ſeaſon, his health, which was naturally delicate, became conſiderably impaired. He began to recover his health, when he again became the victim of his zeal for the ſcience he ſo ſucceſsfully cultivated. He had nearly periſhed by reſpiring the oxygenated muriatic acid gas. A violent attack of convulſive aſthma, which returned during ſeveral days, was the firſt conſequence of this unhappy accident. The diſorder then ſeemed to abate; but it was incurable. The aſſiſtance of art was inſufficient to ſave him; and he died in Paris, on the 21ſt of July 1797, of a pulmonary conſumption, in the flower of his age.

PENDULUM (See *Encycl.*). Beſides the effects of heat and cold on the length of the pendulum rod, and of courſe on its iſochroniſm, it may certainly be worth while, in the conſtruction of clocks intended to meaſure time with the utmoſt poſſible exactneſs, to take into conſideration the reſiſtance of the air, which, by its unequal denſity, varying the weight of the pendulum, muſt in a ſmall degree accelerate or retard its motion. The celebrated David Rittenhouſe, who paid particular attention to this ſubject, eſtimates the extreme difference of velocity, ariſing from this cauſe, at half a ſecond a day; and he obſerves, that a remedy dependent on the barometer will not be ſtrictly accurate, as the weight of the entire column of air does not preciſely correſpond with the denſity of its baſe. He propoſes, therefore, as a very ſimple and eaſy remedy, that the pendulum ſhall, as uſual, conſiſts of an inflexible rod carrying the ball beneath, and continued above the centre of ſuſpenſion to an equal (or an unequal) diſtance upwards. At this extremity is to be fixed another ball of the ſame dimenſions (or greater or leſs, according as the continuation is ſhorter or longer), but made as light as poſſible. The oſcillations of this upper ball will be accelerated by its buoyancy by the ſame quantity as thoſe of the lower would be retarded; and thus, by a proper adjuſtment, the two effects might be made to balance and correct each other.

Our author made a compound pendulum on theſe principles, of about one foot in its whole length. This pendulum, on many trials, made in the air 57 vibrations in a minute. On immerſing the whole in water, it made 59 vibrations in the ſame time; ſhewing evidently, that its returns were quicker in ſo denſe a medium as water than in the air. (This is contrary to what takes place with the common pendulum). When the lower bob or pendulum only was plunged in water, it made no more than 44 vibrations in a minute.

PENNANT (Thomas, Eſq.), ſo well known in the republic of letters as a writer of travels and of natural hiſtory, was an ancient Briton by birth, having drawn his firſt breath in Flintſhire, in 1726. His family has been ſettled in that county for many centuries; we learn from himſelf that he received the rudiments of his education at Wrexham, whence he was removed to Fulham. Soon after this he was ſent to Oxford; and having made a conſiderable proficiency in the claſſics, he applied himſelf within the walls of that univerſity to attain a knowledge of juriſprudence; but we do not find that he ever entered himſelf of any of the inns of court, or followed the law as a profeſſion.

The ruling paſſions of mankind are excited, and the future current of their lives frequently directed, by trivial circumſtances. One of the greateſt painters of our age was attracted with an irreſiſtible impulſe towards his art by the peruſal of a treatiſe on it; and we have the authority of the ſubject of this memoir for aſſerting, that a preſent of Willughby's Ornithology, at an early period, firſt gave him a turn for natural hiſtory, which has never once abandoned him through the courſe of a very long life.

Mr Pennant commenced his travels with great propriety at home, where he made himſelf acquainted with the manners, productions, and curioſities, of his native country, before he ſallied forth to inſpect thoſe of other nations. He then repaired to the continent; and not only acquired conſiderable additional knowledge relative to his favourite ſtudies, but became acquainted, and eſtabliſhed a correſpondence, with ſome of the greateſt men of the age.

On his return he married, and had two children, but did not come into the family fortune until he was thirty-ſeven years of age, at which time he was ſettled at Downing.

Having loſt his wife, he appears to have ſet out once more for the continent, and to have formed an acquaintance with Voltaire, Buffon, Haller, Pallas, &c. He had by this time acquired conſiderable reputation as a ſcientific man, having commenced his career as an author ſo early as 1750. His Britiſh Zoology[*] eſtabliſhed his reputation as a naturaliſt; and this received a freſh acceſſion of celebrity in conſequence of his acquaintance with Linnæus, and his intercourſe by letters with all the celebrated naturaliſts in Europe.

Early in life he had undertaken a moſt intereſting tour to Cornwall; and he now entertained an ardent deſire to ſurvey the works of nature in the northern extremities of the iſland. He accordingly ſet out for Scotland, and in 1771 favoured the public with an entertaining account of his Tour[†], which was ſo well received as to paſs through ſeveral editions. Not content with the main land of Great Britain, he was ambitious to ſurvey the iſlands in the vicinity, and accordingly penetrated to the Hebrides, and viſited Man.

It is not to be ſuppoſed that he would leave his own country unexplored; on the contrary, he minutely deſcribed all its wonders. He did not fail on this occaſion to preſent the world with the reſult of his enquiries, for in 1778 he commenced the publication of his Welch Tour[§].

In four years after this (1782) appeared the account of the Journey from Cheſter to London[‡], in which he refutes the vulgar opinion that it is unintereſting; and in two years more his Arctic Zoology, an admirable work, greatly prized both here and in other countries.

In 1790 appeared a quarto volume, ſimply entitled Of London; in which he obſerves that this work is compoſed from obſervations, originally made without any view of publication. "Let me requeſt (ſays he in the preface) the good inhabitants of London and Weſtminſter not to be offended at my having ſtuffed their Iliad into a nutſhell; the account of the city of London and liberties of Weſtminſter into a quarto volume. I have condenſed into it all I could; omitted nothing that ſuggeſted itſelf; nor amplified any thing to make it a guinea book. In a word, it is done in my own manner, from which I am grown too old to depart.

"I feel within myſelf a certain monitor that warns me (adds he) to hang up my pen in time, before its powers are weakened, and rendered viſibly impaired. I wait not for the admonition of friends. I have the Archbiſhop of Grenada in my eye; and fear the imbecility of human nature might produce in long-worn age the ſame treatment of my kind adviſers as poor Gil Blas had from his moſt reverend patron. My literary bequeſts to future times, and more ſerious concerns, muſt occupy the remnant of my days. This cloſes my public labours."

Notwithſtanding his parting addreſs, the example of the Archbiſhop of Grenada, and the concluding ſentence of "*Valete & Plaudite*," we find Mr Pennant adventuring once more in the ocean of literature, at a late period of his life, and trying his fortune again with all the eagerneſs of a young author.

He accordingly publiſhed the Natural Hiſtory of the pariſhes of Holywell and Downing[*], within the precincts of the latter of which he had reſided about half a century.

He alſo preſented the public, a very ſhort time before his death, with a ſplendid work, conſiſting of 2 vols. 4to. entitled The View of Hindooſtan; in the preface to which he candidly ſtates his motives for this new attempt. "I had many ſolicitations from private friends (ſays he), and a few wiſhes from perſons unknown, delivered in the public prints, to commit to the preſs a part, in the form in which the poſthumous volumes might hereafter make their appearance. I might have pleaded the imprudence of the attempt at my time of life, of beginning ſo arduous an undertaking in my 71ſt year.

"I happily, till very lately, had ſcarcely any admonition of the advanced ſeaſon. I plunged into the ſea of trouble, and with my papers in one hand, made my way through the waves with the other, and brought them ſecure to land. This, alas! is finite boaſting. I muſt ſubmit to the judgment of the public, and learn from thence how far I am to be cenſured for ſo grievous an offence againſt the maxim of Ariſtotle, who fixes the decline of human abilities to the 49th year.

"I ought to ſhudder, when I conſider the wear and tear of 22 years; and feel ſhocked at the remark of the elegant Delanty, who obſerves, 'that it is generally agreed among wiſe men, that few attempts, at leaſt in a learned way, have ever been wiſely undertaken and happily executed after that period!'

"I cannot defend the wiſdom: yet from the good fortune of my life I will attempt the execution."

Theſe valuable volumes are drawn up by Mr Pennant in the manner of his introduction to the Arctic Zoology. The plates, 23 in number, are admirably engraved, and one (the Napaul pheaſant) is beautifully coloured.

In addition to the liſt of literary labours already enumerated, is a letter on an earthquake felt at Downing, in Flintſhire, in 1753; another inſerted in the ſame

[*] Four vols 4to.

[†] Three vols 4to.

[§] Two vols 4to.

[‡] One vol. 4to.

[*] One vol. 4to.

Pennant, Pennatula.

publication*, in 1756, on coralloid bodies (κοραλλοειδης) collected by him: his Synopſis of Quadrupeds, publiſhed in 1771; a pamphlet on the Militia; a paper on the Turkey; and a volume of Miſcellanies.

Mr Pennant attained academical honours of all kinds, having had the degree of LL D. conferred on him by the univerſity in which he was educated, he was a Fellow of the Royal Society, and a member of the Society of Antiquaries, a Fellow of the Royal Society of Upſal in Sweden, a member of the American Philoſophical Society, an honorary member of the Anglo-Linnæan Society, &c.

The ample fortune left him by his father enabled Mr Pennant to keep an hoſpitable table, and alſo to preſent the profits of ſeveral of his works to public inſtitutions, particularly the Welſh charity-ſchool in Gray's-inn-lane. He encouraged ſeveral engravers by his patronage, and was not a little ſerviceable to the advancement of the fine arts.

In 1776 he married a ſecond time; on which occaſion he became united to Miſs Moſtyn, ſiſter of his neighbour, the late Sir Roger Moſtyn, in Flintſhire. The latter part of his life was chearful, and he ſcarcely felt the approaches of old age. He died at his ſeat at Downing in his 72d year.

He has left ſeveral works behind him in MS. under the title of Outlines of the Globe; and as a proof that it will be a very voluminous and intereſting publication, it is only neceſſary to obſerve, that The View of Hindooſtan compoſed the xivth and xvth volumes.

Mr Pennant poſſeſſed a well-compacted frame of body, an open and intelligent aſpect, an active and chearful diſpoſition, and a vivacity which rendered him always entertaining, as well in converſation as in writing. Though not without a ſhare of iraſcibility, his heart was kind and benevolent. He was exemplary in the relations of domeſtic life, and ſenſibly felt for the diſtreſſes of his poor neighbours, whoſe relief in ſeaſons of hardſhip he promoted with great zeal and liberality. His candour and freedom from ordinary prejudices, are ſufficiently diſplayed in his writings; and Scotland was forward to confeſs, that he was the firſt traveller from this ſide the Tweed, who had viſited the country with no unfriendly ſpirit, and had fairly preſented it under its favourable as well as its leſs-pleaſing aſpects. As a writer, his ſtyle is lively and expreſſive, but not perfectly correct. His principles of arrangement in zoology are judicious, and his deſcriptions characteriſtic. If in ſome of his later works a little vanity appears, and a propenſity to think that important to the world which was ſo to himſelf, it may readily be pardoned to one who has afforded ſuch copious and valuable entertainment to the public. His name will live with honour in the literary hiſtory of his country, and his memory will be cheriſhed with reſpect and affection by his ſurviving friends.

PENNATULA (See *Encycl.*). A ſpecies of this animal, hitherto undeſcribed, was diſcovered by La Martiniere near Nootka. Its body is of a cartilaginous ſubſtance, and a cylindrical form; its head, armed with two little horns of the ſame ſubſtance, preſents a ſpherical figure flatted at its anterior extremity. This part is covered with ſmall papillæ, ſome of which are viſible at D, and which ſerve the purpoſe of ſmall mouths, by means of which this animal ſucks the blood of fiſhes, making its way as far as poſſible into the fleſh: the extremity of its body, which always projects from the fiſh, appears like the feathers of a pen; theſe feather-like ſubſtances ſerve as excretory veſſels; for on making a ſlight preſſure on the animal, from the greater part of theſe cartilaginous barbs iſſued ſmall drops of a very limpid liquor: at the baſe of theſe barbs, and beneath the body, are placed two large cartilaginous threads, of which our author could not imagine the uſe, for they are not univerſally met with in each individual. The circulation of its blood is readily obſerved, it forms a complete revolution about once in a minute. It is probable that this animal is only able to make its way into the bodies of different fiſh when it is very young; and when it has once buried itſelf there, having abundance of nouriſhment, its head increaſes conſiderably, and the two horns with which it is furniſhed neceſſarily form an obſtacle to its regreſs, which is a remarkable inſtance of the foreſight of Nature, ſince it is deſtined to be nouriſhed at the expence of another. The pennatula, of which we have given from Martiniere a figure, was found by him at the depth of more than an inch and an half in the body of a *diodon*.

Plate XLI.

* Phil Trans.

Pepuſch.

PEPUSCH (John Chriſtopher), one of the greateſt theoretic muſicians of modern times, as we are told, was born at Berlin about 1667; and became ſo early a proficient on the harpſichord, that at the age of 14 he was ſent for to court, and appointed to teach the prince, father of the late King of Pruſſia. About 1700, he came over to England, and was retained as a performer at Drury Lane: it is ſuppoſed that he aſſiſted in compoſing the operas which were performed there. While he was thus employed, he forebore not to proſecute his private ſtudies; and theſe led him to enquire into the muſic of the ancients, and the peruſal of the Greek authors upon that ſubject. The abilities of Pepuſch, as a practical compoſer, were not likely to become a ſource of wealth to him: his muſic was correct, but it wanted variety of modulation. Beſides, Handel had got poſſeſſion of the public ear, in the opinion of whoſe ſuperior merit he readily acquieſced; and choſe a track for himſelf, in which he was almoſt ſure to meet with no obſtruction. He became a teacher of muſic, not the practice of any particular inſtrument, but muſic in the abſolute ſenſe of the word, that is to ſay, the principles of harmony and the ſcience of practical compoſition; and this, not to children or novices, but in very many inſtances to profeſſors of muſic themſelves.

In 1713, he was admitted to the degree of Doctor in Muſic at Oxford, and continued to proſecute his ſtudies with great aſſiduity. In 1724, he accepted an offer from Dr Berkeley to accompany him to the Bermudas, and to ſettle as profeſſor of muſic in his intended college there; but the ſhip in which they ſailed being wrecked, he returned to London, and married Franceſca Margarita de l'Epine. This perſon was a native of Tuſcany, and a celebrated ſinger, who performed in ſome of the firſt of the Italian operas that were repreſented in England. She came hither with one Greber, a German, and from this connection became diſtinguiſhed by the invidious appellation of *Greber's Peg*. Afterwards ſhe commenced a new connection with Daniel Earl of Nottingham, who had defended the orthodox notion of the Trinity againſt the heretic Whiſton; and to this connection Rowe, in imitation of

Horace's, "Ne ſit ancillæ tibi amor pudori," thus alludes:

Did not baſe Greber's Peg inflame
The ſober Earl of Nottingham,
Of ſober ſire deſcended?
That, careleſs of his ſoul and fame,
To play-houſes he nightly came,
And left church undefended.

She continued to ſing on the ſtage till about 1718; when having, at a modeſt computation, acquired above ten thouſand guineas, ſhe retired from the theatre, and afterwards married Dr Pepuſch. She was remarkably tall, and remarkably ſwarthy; and, in general, ſo deſtitute of perſonal charms, that Pepuſch ſeldom called her by any other name than Hecate, to which ſhe is ſaid to have anſwered very readily.

The change in Pepuſch's circumſtances by Margarita's fortune was no interruption to his ſtudies: he loved muſic, and he purſued the knowledge of it with ardour. At the inſtance of Gay and Rich, he undertook to compoſe, or rather to correct, the muſic for the Beggar's Opera. His reputation was now at a great height. He had peruſed with great attention thoſe ſeveral ancient treatiſes on Harmonics, publiſhed by Meibomius, and that of Ptolemy by Dr Wallis; and the difficulties which occurred to him on the peruſal, were in a great meaſure removed by his friend De Moivre the mathematician, who aſſiſted him in making calculations for demonſtrating thoſe principles on which the harmonic ſcience is founded. In conſequence of theſe ſtudies, he was eſteemed, in matters of theory, one of the beſt muſicians of his time. In 1737, he was choſen organiſt of the Charter-houſe, and retired, with his wife, to that venerable manſion. The wife died in 1740, before which he loſt a ſon, his only child; ſo that he had no ſource of delight left, but the proſecution of his ſtudies, and the teaching of a few favourite pupils, who attended him at his apartments. Here he drew up that account of the ancient genera which was read before the Royal Society, and is publiſhed in the Philoſophical Tranſactions for October, November, and December, 1746; and, ſoon after the publication of that account, he was choſen a Fellow of the Royal Society.

He died the 20th of July, 1752, aged 85; and was buried in the chapel of the Charter-houſe, where a tablet with an inſcription is placed over him *.

PERCUSSION, Force of Percussion, is the name by which mechanicians diſtinguiſh that faculty of producing motion, or making other ſenſible mechanical impreſſions on bodies, by means of the ſtroke of a body in motion. It is nearly the ſame with *impulſe*; only, it would ſeem that the very ſcrupulous and refined affect to limit the attention to the *immediate* cauſe of the motion, or other effect produced; to the ſomething that is different, both from the force ſuppoſed to be inherent in the moving body (a hammer for example), and the ſubſequent motion and penetration of the nail which is driven by it. We may venture to ſay that it is needleſs to attempt any inveſtigation of this object. It is hid, with all other cauſes of all other effects in the univerſe, in impenetrable darkneſs. If we reflect on the conſtitution of our own mind, ſo far as we can know it by experience and obſervation, and on the manner in which we draw concluſions, we muſt ſee that the knowledge of the efficient cauſe of any effect is unattainable; for were the intervening ſomething pointed out to us, and clearly conceived by us, we ſhould find it juſt as neceſſary to find out why and how this ſomething is connected with each of the events which we obſerve it invariably to connect.

But a knowledge of the force of percuſſion, in as far as it may or may not be diſtinguiſhable from other forces, is not unattainable. We can learn as much, and no more, concerning this, as concerning any other force; and we can contemplate that circumſtance which, in our opinion, is common to it with all other forces, and may perhaps diſcover other circumſtances in which it differs from them. But in all this diſquiſition, it is plain that it is only events, which we conceive to be the characteriſtic effects of the cauſe, that we contemplate.

Percuſſion, conſidered as an effect, characteriſtic of a particular faculty of moving bodies, became an object of anxious reſearch, almoſt as ſoon as philoſophers began to think of motion and moving forces at all. The ancients (as has been obſerved in the article Impulsion, *Suppl.*) contented themſelves with very vague ſpeculations on the ſubject. Galileo was the firſt who conſidered it as a meaſurable thing, the object of mathematical diſcuſſion; being encouraged by his precious diſcovery of the laws of accelerated motion, and the very refined meaſure which theſe gave him of the power of gravity. It was a meaſure of the heavineſs, not of the weight, of the body; and this was meaſured by its acceleration, and not by its preſſure. Encouraged by this, he hoped to find ſome ſuch meaſure of the force of percuſſion, which he ſaw ſo intimately connected with motion; whereas its connection with preſſure was far from being obvious. He therefore tried to convert the terms; and as he had found a meaſure of the preſſure of gravity in the acceleration of motion, he endeavoured to find in preſſure a meaſure of the force of percuſſion ariſing from this acceleration. He endeavoured to find the number of pounds, whoſe preſſure is equal to the blow of a given body, moving with a given velocity. The velocity was known to him with great preciſion, by means of the height from which the ball muſt fall in order to acquire it. It ſeems pretty clear that percuſſion may be meaſured in this way; for a body falling from a height will pierce an uniformly tenacious body to a certain degree, and no further; and experiment ſhews that this degree of penetration is very preciſe and conſtant. The ſame body, being merely laid on the tenacious body, will penetrate to a ſmall depth by its weight. Laying more weight on it, will make it penetrate deeper; and a certain weight will make it penetrate as deep as the fall did, and no deeper. Thus, percuſſion ſeems very eaſily meaſurable by weight, or by any preſſure ſimilar to that of weight. It appears that Galileo made experiments with this view, and that he was diſappointed, and obliged to acquieſce in the opinion of Ariſtotle, that percuſſion and weight are incomparable. He propoſes, therefore, another experiment, namely, to drop a body into the ſcale of a balance from greater and greater heights, till at laſt the blow on the ſcale raiſes a weight that lies in the other ſcale. This offers itſelf ſo plauſibly, that we are perſuaded that Galileo tried it: but as he makes no mention

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* Biog. Dict. new edit.

tion of the reſults, we preſume that they were unſatiſfactory.

Neither of theſe experiments *could* give us a meaſure of the force of percuſſion, if this force be any thing different from the forces which are excited or brought into action by percuſſion, in the manner deſcribed in the article IMPULSION, *Suppl.* When the ball comes into phyſical contact with the ſcale, it begins to compreſs it. This compreſſion begins to ſtretch the ſtrings by which the ſcale is ſupported. Theſe pull at the arm of the balance, and cauſe it to preſs the centre-pin a little harder on its ſupport, and to bend the balance a little, and cauſe it to pull at the cords which ſupport the other ſcale. That ſcale is pulled upwards, diminiſhing a little its preſſure on the ground, and preſſing it harder to the incumbent weight. Theſe forces are excited *in ſucceſſion* from the one ſcale to the other, and a ſmall moment of time elapſes. The reaction of the ſcale diminiſhes, but does not inſtantaneouſly annihilate, the velocity of the falling ball. It therefore compreſſes the ſcale ſtill more, ſtretches the threads, preſſes the fulcrum, and bends the balance ſtill more (becauſe the weight in the other ſcale keeps it down). The velocity of the falling ball is rapidly diminiſhed; the balance is more bent, and pulls more ſtrongly upwards at the threads of the other ſcale; and thus preſſes that ſcale more ſtrongly againſt the incumbent weight, gradually communicating more and more motion to it, removing it farther from the ground, till, at laſt, the motion becomes ſenſible, or ſo conſiderable as to diſengage ſome delicate catch as a ſignal. The experiment is now finiſhed; and the mechanician fondly thinks that, at this inſtant, the preſſure excited by the percuſſion, between the oppoſite ſcale and the under ſide of the incumbent weight, is juſt equal, or but a very little ſuperior, to the preſſure of the incumbent weight: and, ſince the arms of the balance are equal, and therefore the preſſures on the two ſcales are equal, he imagines that that weight exerts a preſſure equal to the percuſſion of the falling ball.

But all this is miſconception, and alſo falſe reaſoning. It is not percuſſion that we are meaſuring, but the preſſures, excited by percuſſion, on the two ſcales. And theſe preſſures are the forces of elaſticity or expanſiveneſs, belonging to, or inherent in, the particles of the balls and the ſcales; forces which are brought into action by the approach of thoſe bodies to each other. This reaſoning is alſo erroneous; and we ſhould be miſtaken if we think that the preſſure actually exerted is equal to that of the weight in the oppoſite ſcale. It is greater than the mere preſſure of that weight. The reaction of the oppoſite ſcale on its load was preciſely equal to that weight before the ball was dropped from the hand; and, had the ball been equal to that weight, and ſimply laid into the ſcale on which it falls, it would have made no change on the mutual preſſures of the ſcale and the other weight; it would only have relieved the ground from the preſſure of that weight, and would have brought it on the threads which ſupport its ſcale. The preſſure of this ſcale upwards muſt be increaſed, before it can ſtart the weight ſenſibly from the ground. How much it muſt be increaſed depends on the ſpringineſs of the ſcales, cords, and beam. By a proper adjuſtment of theſe particulars, the apparatus will give us almoſt any meaſure of percuſſion that we chooſe. For this reaſon, the improvements made on it by Graveſande are of no value. The ſame reaſoning, nearly, may be applied to the meaſurements of the force of percuſſion by means of the penetration of ſoft bodies.

Galileo mentions another very curious experiment, by which he thought that he had obtained a juſt meaſure of percuſſion. A veſſel, filled with water, was ſuſpended on the arm of a balance, with another veſſel hanging from it, a great way below. All was exactly balanced by a weight in the oppoſite ſcale. By means of a ſuitable contrivance, a hole was opened in the bottom of the upper veſſel, without diſturbing the equilibrium. As ſoon as the water iſſued, and while it was falling through the air, that end of the balance roſe; but when the water ſtruck the lower veſſel, the equilibrium was reſtored, and continued during the whole time of the efflux. Hence Galileo concluded, that the force of the ſtroke was equal to the weight of the falling water. But we apprehend that the obſervations made on this in the article IMPULSION, *Suppl.* will convince the reader that this concluſion is far from being legitimate. Beſides, the ſtroke, in any one inſtant, is made by thoſe particles only which ſtrike in that inſtant, while the whole vein of water between the veſſels is neither acting by its weight on the upper veſſel, nor by its ſtroke on the lower; and we ſhould conclude from the experiment, that the force of percuſſion is infinitely greater than the weight of the ſtriking body. Indeed this is the inference made by Galileo. But if we have recourſe to the experiments and reaſonings of Daniel Bernoulli, in the article *RESISTANCE of Fluids, Encycl.* we ſhall find that the ſeeming impulſe on the lower veſſel is really a moſt complicated pure preſſure, and of moſt uncertain determination. The experiment is valuable, and gives room for curious reflections. We have repeated it, in a great variety of forms, and with great changes of impulſe, and ſometimes in ſuch a manner that no impulſe whatever can obtain, while at the ſame time a quantity of water was falling, unſupported by either veſſel. In all the trials the equilibrium remained undiſturbed. We were obliged to conclude, therefore, that the experiment afforded no meaſure of percuſſion. Indeed we were of this opinion before making the trial, for the reaſons juſt now given.

We cannot ſay that the ſubſequent labours of philoſophers have added much to our knowledge of this matter. Mr Leibnitz had contrived his whimſical doctrine of *living* and *dead* forces. The action of gravity, or of a ſpring, is a *vis viva*, when it actually produces motion in the body on which it acts: but when a ſtone lies on a table, and preſſes on it, this preſſure is a *vis mortua*. Its exertion is made, and in the ſame inſtant deſtroyed, by an oppoſite *vis mortua*. Each of theſe exertions would have produced *a beginning* of motion (ſomething different from any the ſmalleſt local motion); and the ſum of all would, after a certain time, have amounted to a ſenſible motion and velocity. There ſeems no diſtinct conception to accompany, or that can accompany, this language. And, as a proof that Leibnitz had no diſtinct conceptions of the matter, he has recourſe to this very experiment of Galileo in ſupport of his geneſis of a ſenſible motion from the continual exertions of the *vis mortua*; and he concludes that the force of percuſſion is infinitely, or incomparably, greater than preſſure, becauſe it is the ſum total of an infinity of individual exertions of *vis mortua*. Nothing but the authority which Leibnitz has acquired on the continent, by the zealous efforts of his partizans, could excuſe our taking up any time in conſidering this unintelligible diſcourſe. Surely, if there is ſuch a thing as a *vis viva*, it exiſts in the moving water, and its impulſions are not continual exertions of a *vis mortua*. Nor is it poſſible to conceive continual impulſe, nor a beginning of motion that is not motion, &c. &c. It is paradoxical (and Leibnitz loved to raiſe the wonder of his followers by paradoxes) to ſay that percuſſion is infinitely greater than preſſure, when we ſee that preſſure can do every thing that can be done by percuſſion. Nay, Euler, by far the moſt able ſupporter of the doctrines of Leibnitz about the force of bodies in motion, actually compares theſe two forces; and, in his Commentary on Robins's Artillery, demonſtrates, in his way, that when a muſket ball, moving with the velocity of 1700 feet per ſecond, penetrates five inches into a block of elm, the force of its percuſſion is 107,760 times its weight. John Bernoulli reſtricts the infinite magnitude of percuſſion to the caſe of perfectly hard bodies; and, for this reaſon alone, ſays, that there can be none ſuch in the univerſe. But, as this juſtly celebrated mathematician ſcouts with ſcorn the notion of attractions and repulſions, he muſt allow, that an ultimate atom of matter is unchangeable in its form; which we take to be ſynonymous with ſaying that it is perfectly hard. What muſt be the reſult of one atom in motion hitting another at reſt? Here muſt be an inſtantaneous production of a finite velocity, and an infinite percuſſion. A doctrine which reduces its abetters to ſuch ſubterfuges, and engages the mind in ſuch puzzling contemplations, cannot (to ſay the beſt of it) be ſtyled an EXPLANATION of the laws of Nature. The whole language on the ſubject is full of paradoxes and obſcurities. In order to reconcile this infinite magnitude of percuſſion with the obſerved finite magnitude of its effects, they ſay that the preſſure, or inſtantaneous effort, has the ſame relation to the force of percuſſion that an element has to its integral; and in maintaining this aſſertion, they continually conſider this integral under the expreſs denomination of a *ſum total*, robbing Leibnitz's great diſcovery of the infiniteſimal calculus of every ſuperiority that it poſſeſſed over Wallis's Arithmetic of Infinites, and really employing all the erroneous practices of the method of indiviſibles. We look upon the ſtrange things which have been inculcated, with pertinacious zeal, in this doctrine of percuſſion and *vires vivæ*, as the moſt remarkable example of the errors into which the unguarded uſe of Cavalerius's Indiviſibles, and of the Leibnitzian notion of the infiniteſimal calculus, have led eminent mathematicians. It is not true that the preſſure, and the ultimate force of percuſſion, have this relation; nor has the preſſure and the reſulting motion, which is miſtaken for the meaſure of this ultimate force, any mathematical relation whatever. The relation is purely phyſical; it is the relation of pure cauſe and effect; and all that we know of it is their conſtant conjunction. The relation of fluxion and fluent is not a mathematical or meaſurable relation, but a connection in thought; which is ſufficient for making the one an indication of the other, and the meaſures of the proportions of the one a mean for obtaining a meaſure of the proportions of the other. In this point of view, the relation of preſſure to motion, as the meaſure of the force of percuſſion, *reſembles* that of fluxion and fluent, but is not the ſame.

Much has been ſaid by the partizans of Mr Leibnitz about the incomparableneſs of preſſure and percuſſion, and many experimental proofs have been adduced of the incomparable ſuperiority of the latter. Bulfinger ſays, that the preſſure of many tons will not cauſe a ſpike to penetrate a block of hard oak half ſo far as it may be driven by a weak man with one blow of a mallet; and that a moderate blow with a ſmall hammer will ſhiver to powder a diamond, which would carry a mountain without being hurt by its preſſure. Nay, even Mr Camus, of the Academy of Paris, a ſtaunch Carteſian, and an eminent mechanician, ſays that he beat a leaden bullet quite flat with a hammer of one pound weight, without much force; and that he found that 200 pounds weight would not have flattened it more than this blow: and he concludes from thence, that the force of the blow exceeded 200 pounds. Theſe, to be ſure, are remarkable facts, and juſtify a more minute conſideration of a power of producing certain effects, which is ſo frequently and ſo uſefully employed. But, at the ſame time, theſe are all very vague expreſſions, and they do not authoriſe any preciſe concluſions from them. Mr Camus ſaying "without much force," makes his pound weight, and his 200 pound weight, of no uſe for determining the force of the blow. He would have given more preciſe and applicable data for his deciſion, had he told us from what height the hammer ſhould fall in order to flatten the bullet to this degree. But even then we ſhould not have obtained any notion of the force in actual exertion during the flattening of the bullet; for the blow which could flatten the bullet in a longer or a ſhorter time, would unqueſtionably have been leſs or greater.

All the paradoxes, obſcurities, and puzzling difficulties, in this ſubject diſappear, if we leave out of our conſideration that unintelligible force, which is ſuppoſed to preſerve a body in motion or at reſt; and if we conſider both of theſe ſtates of body as conditions which will continue, unleſs ſome adequate cauſe operate a change; and if we farther grant, that ſuch cauſes do really exiſt in the univerſe, however unknown their nature may be by us; and, laſtly, if we acknowledge, that the phenomena of elaſticity, expanſiveneſs, coheſion, gravity, magnetiſm, electricity, are indications of the agency of ſuch cauſes, and that their actual exertions, and the motions and changes conſequent on theſe exertions, are ſo invariably connected with particular bodies, that they always accompany their appearance in certain mutual relations of diſtance and poſition:—if we proceed thus, all the phenomena of colliſion will be explained by theſe cauſes alone, without ſuppoſing the exiſtence and agency of a cauſe diſtinct from them all, and incomparable with them, called the FORCE OF PERCUSSION.

For it has been ſufficiently demonſtrated in the article IMPULSION (*Suppl.*), that that property of tangible coherent matter, which we call *perfect elaſticity*, operates as a preſſure during a certain ſmall portion of time on both bodies, diminiſhing more and more the motion of the one, and augmenting that of the other, as the compreſſion of one or both increaſes, till at laſt they ſeparate with ſenſible velocities. In ſome very ſimple or perſpicuous caſes, we know what this preſſure is in every inſtant of the action. We can tell how many pounds weight, at reſt, will exert the ſame preſſure. We can tell the whole duration of this preſſure, and the ſpace along which it is exerted; and, in ſuch a caſe, we can ſay with preciſion what motion will be generated by this continued and varied preſſure on the body which was at reſt, and what diminution will be made in the motion of the other. All this can be done in the caſe Plate XLI. of a ball A (fig. 1.), moving like a pendulum with a ſmall velocity, and ſtriking a ſlender elaſtic hoop B, alſo ſuſpended like a pendulum. We can aſcertain by experiment, before the colliſion, what preſſure is neceſſary for compreſſing it one inch, one-half, one-fourth, &c. Knowing this, and the weight of the hoop, and the weight and velocity of the ball, we can tell every circumſtance of the colliſion—how long the compreſſion continues—what is the greateſt compreſſion—how far the bodies have moved while they were acting on each other—and what will be the final motion of each:—in ſhort, every thing that affords any mark or meaſure of a force of percuſſion. And we know that all this is produced by a force, familiarly known to us by the name of elaſticity. Which of all theſe circumſtances ſhall be called the percuſſion, or the force of percuſſion? Is it the ultimate or greateſt preſſure occaſioned by the compreſſion? This cannot be, becauſe this *alone* will not be proportional to the final change of motion, which is generally taken as a meaſure of the percuſſion when a change of motion is its only obſerved effect.

We know that another perfectly elaſtic body, of the ſame weight, and ſtruck by the ſame blow, and acquiring the ſame final velocity by the ſtroke, may not have ſuſtained the tenth part of the preſſure, in any one inſtant of the colliſion, if it has only been much more compreſſible The greateſt mutual preſſure in the colliſion of a billiard ball is perhaps 1000 times greater than it is in a ſimilar colliſion of a foot-ball of the ſame weight.

We alſo know what degree of compreſſion will break this hoop, and what preſſure will produce this compreſſion. Therefore, ſhould the fracture of the body be conſidered as the mark and meaſure of the percuſſion, we know what blow will juſt produce it, and be exhauſted by ſo doing. In ſhort, we know every mark and meaſure of percuſſion which this hoop can exhibit.

We can increaſe the ſtrength of this hoop till it becomes a ſolid diſk; and we ſee clearly, that in all theſe forms the mode of acting is the ſame. We ſee clearly that it is the ſame when, inſtead of the ſolid diſk, it is an elaſtic ball; therefore every thing that can indicate or meaſure the percuſſion of an elaſtic ball, is explained without the operation of a peculiar force of percuſſion, even when the ball is ſhivered to pieces by the blow.

Nor is the caſe materially different when the bodies are ſoft, or imperfectly elaſtic. When the ſtruck body is uniformly tenacious, it oppoſes a uniform reſiſtance to penetration, and its motion will be uniformly accelerated by the action of its own tenacity during the whole time of mutual action, except a trifling variation occaſioned by the mere motion of the internal parts, independent of their tenacity. If we knew the weight neceſſary for merely penetrating this maſs, and the weight and velocity of the penetrating body, we can tell how long it muſt be reſiſted by this force before its initial velocity will be annihilated, and therefore how far it will penetrate. We have tried this with deal, birch, willow, and other ſoft woods of uniform texture, and with nails having the body ſomewhat ſlenderer than the end, that there might not be an irregularity occaſioned by a friction on the ſides of the nail, continually increaſing as the penetration advanced. We made the hammer fall from a conſiderable height, and hit the nail with great accuracy in the direction of its length, by fixing it to the end of a long lath, moveable round an axis. The reſults correſponded with the calculation with all the preciſion that could be deſired.

But it does not reſult from all this agreement, that the force, exertion, or effect, of a blow with a hammer is equal to the preſſure of any number of pounds whatever. They are things that cannot be compared; and yet the force operating in the penetration by a blow is no way different from a preſſure. It is a phyſical blunder to compare the area of the curve, whoſe abſciſſa is the depth of penetration, and the ordinates are as the reſiſtances, with any preſſure whatever. This area expreſſes the ſquare of a velocity, and its ſlips, bounded by parallel ordinates indefinitely near each other, are as the decrements of this ſquare of a velocity, occaſioned by a preſſure, acting almoſt uniformly along a very ſmall ſpace, or during a very ſmall time. It is an abſurdity therefore to ſum up theſe ſlips as ſo many preſſures, and to conſider the ſum total as capable of expreſſing any weight whatever. Such a paralogiſm is peculiar to Leibnitz's way of conceiving his infiniteſimal method, and it could have no place in the genuine method of fluxions. It is this miſconception that has made Mr Leibnitz and his followers ſuppoſe that a body, accelerated by gravity, retains in it a ſum total of all the preſſures of gravity accumulated during its fall, and now forming a *vis viva*. Suppoſing that it requires a preſſure of twenty pounds to preſs a ſix pound ſhot ſlowly through a maſs of uniformly reſiſting clay; this preſſure would carry it from the top to the bottom of a mountain of ſuch clay. Yet this ball, if diſcharged horizontally from a cannon, would penetrate only a few yards, even though the clay ſhould reſiſt by tenacity only, independent of the motion loſt by giving *motion* to its internal parts. In this experiment, the utmoſt preſſure exerted during the motion of the ball did not much exceed the preſſure of twenty pounds. In this compariſon, therefore, percuſſion, ſo far from appearing infinitely greater than preſſure, would appear much leſs. But there is perhaps no body that reſiſts penetration with perfect uniformity, even though uniformly tenacious. When the ball has penetrated to ſome depth, the particles which are before it cannot be ſo eaſily diſplaced, even although they had no tenacity, becauſe the particles adjoining are more hemmed in by thoſe beyond them. We have always obſerved, that a ball impelled by gunpowder through water riſes toward the ſurface (having entered horizontally through the ſide of the veſſel at ſome depth), and this ſo much the more rapidly as it entered nearer to the ſurface. The reaſon is plain. The particles which muſt be diſplaced before the ball, eſcape more eaſily upwards than in any other direction. It is for this reaſon chiefly that a greater weight laid on the head of a nail will cauſe it ſink deeper into the wood; and thus a great weight appears to be commenſurable with a great force of percuſſion. Alſo, while a bullet is flattening more and more under a hammer during the progreſs of a blow, it is ſpreading under the hammer; more particles are reſiſting at once, and they find more difficulty in effecting their eſcape, being harder ſqueezed between the hammer and the anvil. The ſame increaſed reſiſtance muſt obtain while it is flattening more and more under the quiet preſſure of a weight; and thus, too, a greater weight appears to be commenſurable with a greater blow.

After all, however, a blow given by a falling body muſt excite a preſſure greater than its mere weight can do, and this in any degree. Thus, ſuppoſe AB (fig. 2.) to repreſent a ſpiral ſpring in its natural unconſtrained dimenſions, ſtanding upright on a table. Let *a b* be the abſciſſa of a line *a d b k*, whoſe ordinates *c d*, *g b*, *i k*, &c. are as the elaſtic reaction of the ſpring when it is compreſſed into the lengths *c b*, *g b*, *i b*, &c. Suppoſe that, when it is compreſſed into the form CD, it will juſt ſupport the weight of a ball lying on C. Then *c d* will be a reaction equal to the weight of the ball, and the rectangle *a c d f* will expreſs the ſquare of the velocity which this ball would acquire by falling freely through *a c*. If therefore the ball be gently laid on the top of the ſpring at A, and then let go, it will deſcend, compreſſing the ſpring. It will not ſtop when the ſpring has acquired the form CD, which enabled it to carry the weight of the ball gently laid on it. For in this ſituation it has acquired a velocity, of which the ſquare is repreſented by the figure *a d f* (See DYNAMICS, *Suppl.* n° 95.). It will compreſs the ſpring into the length *g b*, ſuch that the area *c g b d* is equal to the area *a d f* If the ball, inſtead of being gently laid on A, be dropped from M, it will compreſs the ſpring into ſuch a length *i b*, that the area *a i k* is equal to the rectangle *m c d n*; and, if the ſpring cannot bear ſo great compreſſion, it will be broken by this very moderate fall.

Thus we ſee that a blow may do things which a conſiderable preſſure cannot accompliſh. The accounts which are given of theſe remarkable effects of percuſſion, with the view of impreſſing notions of its great efficacy, are generally in very indefinite terms, and often without mentioning circumſtances which are acceſſory to the effect. It would be very unfair to conclude an almoſt infinite power of percuſſion, from obſerving, that a particle of ſand, dropped into a thick glaſs bottle which has not been annealed, will ſhiver it to pieces. When Mr Bulfinger ſays that a moderate blow will break a diamond which could carry a mountain, he not only ſays a thing of which he cannot demonſtrate the truth, and which, in all probability, is not true; but he omits noticing a circumſtance which he was mechanician enough to know would have a conſiderable ſhare in the effect. We mean the rapidity with which the excited preſſure increaſes to its maximum in the caſe of a blow. In the experiment in queſtion, this happens in leſs than the millionth part of a ſecond, if the velocity of the hammer has been ſuch as a man would generate in it by a very moderate exertion. For the blow which will drive a good lath nail to the head in a piece of ſoft deal with an ordinary carpenter's hammer, muſt be accounted moderate. This we have learned by experiment to be above 25 feet per ſecond. The connecting forces exerted between the particles of the diamond may not have time ſufficient for their excitation in the remote parts, ſo as to ſhare the derangement among them all, in ſuch a manner that it may be ſo moderate in each as not to amount to a diſunion in any part of the diamond. We ſee many inſtances of this in the abrupt handling of bodies of tender and friable texture. It is partly owing to this that a ball diſcharged from a piſtol will go through a ſheet of paper ſtanding on edge without throwing it down, which it would certainly do if thrown at it by the hand. The connecting forces, having time to act in this laſt caſe, drag the other parts of the paper along with them, and their union is preſerved. Alſo, when a great weight is laid on the diamond, it is gradually dimpled by it; and thus incloſing many parts together in the dimple, it obliges them to act in concert, and the derangement of each is thus diminiſhed.

We flatter ourſelves that the preceding obſervations and reflections will contribute ſomewhat towards removing the paradoxes and myſteries which diſcredit, in ſome degree, our mechanical ſcience. If we will not pertinaciouſly conjure up ideal phantoms, which, perhaps, *cannot* exiſt, but content ourſelves with the ſtudy of that tangible matter which the Author of Nature has preſented to our view, we ſhall have abundant employment, and ſhall perceive a beautiful harmony thro' the whole of natural operations; and we ſhall gradually diſcover more and more of thoſe mutual adaptations which enable an atom of matter, although of the ſame preciſe nature wherever it is found, to act ſuch an unſpeakable variety of parts, according to the diverſity of its ſituations and the ſcene on which it is placed. If a mind be "not captivated by the harmony of ſuch ſweet ſounds," we may pronounce it "dark as Erebus, and not to be truſted."

PERFECT NUMBER, is one that is equal to the ſum of all its aliquot parts when added together. Eucl. lib. 7, def. 22. As the number 6, which is $= 1 + 2 + 3$, the ſum of all its aliquot parts; alſo 28, for $28 = 1 + 2 + 4 + 7 + 14$, the ſum of all its aliquot parts. It is proved by Euclid, in the laſt prop. of book the 9th, that if the common geometrical ſeries of numbers 1, 2, 4, 8, 16, 32, &c. be continued to ſuch a number of terms, as that the ſum of the ſaid ſeries of terms ſhall be a prime number, then the product of this ſum by the laſt term of the ſeries will be a perfect number.

PERGUNNA, in Bengal, the ſubdiviſion of a diſtrict.

PERKINISM, the proper name of what we muſt think an impoſition attempted to be put upon the world by Dr Perkins of North America.

Though the phenomena of electricity had been long familiar to the philoſophers of Europe, it is well known that a philoſophical theory of theſe phenomena was firſt formed by a tranſatlantic philoſopher. In like manner, though the diſcovery of Galvani, under the name of *animal electricity* (ſee GALVANISM in this *Supplement*), had occupied the attention of many of the firſt phyſicians and philoſophers of the old world, it was reſerved for a phyſician of the new, to apply it to the cure of a number of diſeaſes. Every philoſopher of America, however, has not the ſagacity of the Philadelphian ſage; nor muſt Dr Perkins or his admirers be ſurpriſed, if we treat not incomprehenſible myſticiſm with the reſpect due to a theory founded on facts.

We are told by the ſon (a) of this rival of Franklin, that before the news of Galvani's diſcovery had reached America, he had obſerved ſeveral phenomena pointing out the influence of metals in caſes of pain. The firſt remarkable incident that preſented itſelf to his notice was the ſudden contraction of a muſcle when he was performing a chirurgical operation. This, he obſerved, regularly took place whenever the point of the metallic inſtrument was put in contact with the muſcle. Struck with the *novelty* of the appearance (Is Mr Perkins ſure that the appearance was new?), he was induced to try the points of wood and other ſubſtances; and no contraction taking place on theſe experiments, he thence inferred that the phenomena could be aſcribed only to the influence of the metal. About the ſame time, he obſerved that, in one or two caſes (and if his practice had been great he might have obſerved that in a thouſand caſes), a ceſſation of pain had enſued when a knife or lancet was applied to ſeparate the gum from a tooth previous to extracting it; and in the ſame year he diſcovered, that *momentary* eaſe was given, in a few inſtances, by the accidental application of a metallic inſtrument to inflamed and painful tumors previous to any inciſion.

Theſe are the judicious reaſonings and aſſertions of a dutiful child, who, having probably heard of Leibnitz's claims to ſome of Newton's diſcoveries, was determined to put in a ſimilar claim for his father, to a *ſhare*, at leaſt, of the diſcovery made by the celebrated profeſſor at Bologna. He has not, however, copied with ſervility the conduct of the Leibnitzians. We do not remember an inſtance where any of them attempted to elevate the fame or the merits of their maſter *above* the fame and merits of Newton; but, according to our author, the purſuits of Galvani and his European pupils ſink into inſignificance, when compared with thoſe of the tranſatlantic phyſician.

This is evident; for when the phyſiologiſts of Europe were engaged in experimenting on the denuded nerves and muſcles of the ſmaller animals, with a view to aſcertain the agency of this incomprehenſible property in them, Dr Perkins was proſecuting a ſeries of experiments, which conſiſted in applying externally, to parts affected with diſeaſe, metals, and compounds of metals of every deſcription which occurred to him, and conſtructed into various forms and ſizes. The reſult proved, that on drawing lightly over the parts affected certain inſtruments, termed *tractors*, which he formed from metallic ſubſtances into pointed ſhapes, he could remove moſt of thoſe topical diſeaſes of the human body, where an extra degree of nervous energy or vital heat was preſent; unleſs ſuch diſeaſe was ſituated in ſome of the internal viſcera, too remote from the part where the inſtruments could be applied.

The diſeaſes which have been found moſt ſuſceptible of the influence of the tractors are, rheumatiſm, ſome gouty affections, pleuriſy, ophthalmias, eryſipelas, violent ſpaſmodic convulſions, as epileptic fits and the locked jaw, the pain and ſwelling attending contuſions, inflammatory tumors, the pains from a recent ſprain, the painful effects of a burn or ſcald, pains in the head, teeth, and indeed moſt kinds of painful topical affections, excepting where the organic ſtructure of the part is deſtroyed, as in wounds, ulcers, &c. and excepting alſo where oils or ſome other non-conducting ſubſtances are preſent.

But we have other teſtimonies than thoſe of Dr Perkins and his ſon for the influence of the tractors. Mr Meigs, profeſſor of natural philoſophy at Newhaven, in a letter on Dr Perkins's diſcovery, conceives the principles of metallic irritability as ſo little underſtood, that he will not pretend to explain how the tractors produce their effects; but ſeems ſatisfied in finding that the effects are produced. After ſtating an experiment on his own child, eight years of age, very dangerouſly ill with a peripneumonic complaint, and to which the tractors gave almoſt inſtantaneous relief, he ſays, "I have uſed the tractors with ſucceſs in ſeveral other caſes in my own family; and although, like Naaman the Syrian, I cannot tell why the waters of Jordan ſhould be better than Abana and Pharpar, rivers of Damaſcus; yet, ſince *experience* has proved them ſo, no reaſoning can change the opinion. Indeed, the cauſes of all common facts are, *we think*, perfectly well known to us; and it is very probable, fifty or an hundred years hence, we ſhall as well know why the metallic tractors ſhould in a few minutes remove violent pains, as we now know why cantharides and opium will produce oppoſite effects: viz. we ſhall know but *very little* about either, excepting *facts*."

Mr Woodward, profeſſor of natural philoſophy at Dartmouth, in a letter alſo on the ſame ſubject, has ſtated a number of ſucceſsful experiments in pains of the head, face, teeth, and in one caſe of a ſprain.

Dr Vaughan, a member of the Philadelphia medical ſociety, has lately publiſhed an ingenious tract on Galvaniſm, the object of which is to account for the influence of the tractors in removing diſeaſes. After a citation of numerous experiments made on the nerves and muſcles of animals, he obſerves, "If we only take an impartial view of the operations of Nature herſelf, and attend diligently to the analytical inveſtigations of the aforementioned experimentaliſts on this ſublime ſubject, I think the ſceptic muſt admit that the principle of nervous energy is a modification of electricity. As ſenſation is dependant on this energy, a pleaſurable ſenſation, or what may be termed a natural or healthy degree thereof; then certainly pain, or ſuperſenſation, can only depend on an accumulation of the electric fluid, or extra degree of energy in the part affected. On this principle the problem admits of eaſy ſolution; namely, that the metals, being ſuſceptible of this fluid, conduct the extra degree of energy to parts where it is diminiſhed, or out of the ſyſtem altogether, reſtoring the native law of electric equilibrium."

We truſt we are not ſceptics; and yet we feel not ourſelves inclined to admit any part of this theory. We have ſeen no proof that nervous energy is a modification of electricity; and we think that we have ourſelves proved, that *galvaniſm* and *electricity* are in many reſpects different; but we ſhall not be much ſurpriſed if we ſoon ſee a *demonſtration* by ſome American or German philoſopher, that the ſoul of man is a compoſition of ſilver and zinc. One of theſe ſages has lately diſcovered, that the ſymptoms of *putrefaction* do not conſtitute an *infallible* evidence of death, but that the application of *metals* will in all caſes aſcertain it beyond the poſſibility of doubt! A proper application certainly will; for when the Perkiniſt is doubtful whether his patient be dead or alive, he has only to apply the muzzle of a loaded piſtol to his temple, and blow out his brains; after which he may ſafely ſwear that the man is dead.

(a) See a pamphlet, entitled The Influence of Metallic Tractors on the Human Body, &c. by Benjamin Douglas Perkins, A. M. ſon to the diſcoverer; or a very good abridgement of it in the firſt volume of the Philoſophical Magazine.

From the *Philoſophical Magazine*, we learn that Profeſſor Schumacher at Copenhagen made experiments with tractors of braſs and iron on ten patients in Frederick's hoſpital at Copenhagen. He tried alſo tractors of ebony and ivory, which are ſaid to have cured a pain in the knee; with others of ſilver and zinc; and ſome of copper and lead. By the two laſt, pains in the knee, arm, and face, are ſaid to have been mitigated. According to M. Klingberg's experiments, this remedy was of uſe in *malum iſchiaticum*; and according to thoſe of M. Steffens, in *malum iſchiaticum* and megrim. According to M. Bang, the pains in ſome caſes were increaſed, and in others allayed. According to M. Blech, the tractors were of uſe in *hemicrania* and gouty pains in the head; and, according to M. Hahn, in rheumatic pains in both ſhoulders. The principal document in the Daniſh collection relating to Perkiniſm, appears to be a letter of Profeſſor Abilgaard, in whoſe opinion Perkins's tractors will never acquire much value in medicine, and ſcarcely even have the merit of being a palliative; but, in a phyſical point of view, he thinks they deſerve the attention of phyſicians, and particularly of phyſiologiſts. Mankind (he ſays) hitherto have paid too little attention to the influence which electricity has on the human body; otherwiſe they would know that the effects produced on it by our beds is no matter of indifference. If the feather beds and hair mattreſſes, &c. are perfectly dry, the perſon who ſleeps on them is in an inſulated ſtate; but the contrary is the caſe if they are moiſt. He three times removed a pain in the knee, by ſticking the tractors, one on each ſide of the knee, ſo deep through the ſtockings that the points touched the ſkin. He removed a rheumatic pain in the head from a lady by the ſame means. M. Kaſn, by the tractors, relieved, in others, gouty pains of the head and megrim; and in himſelf, a rheumatic pain of the back, which, according to his ſenſations, was like a conſtriction in the cellular tiſſue. M. Herholdt, from his experiments, conſiders the effect of the tractors as indefinite and relative as that of other remedies. He, however, ſaw relief given by them in the ſtrangury in a caſe of ſyphilis. M. Bang alſo, at Soroe, freed a man from a violent gouty pain in the thigh, by drawing the tractors 200 times over the affected part. M. Jacobſen likewiſe found benefit derived from theſe tractors ſeveral times in the common hoſpital at Copenhagen. M. Tode tried them alſo in rheumatic pains, tooth-ache, and inflammation of the eyes; and obſerved that they neither did good nor harm.

On ſome of the atteſted cures mentioned in Mr Perkins's pamphlet, an able writer in the Monthly Review has made remarks ſo very pertinent, that we cannot refuſe ourſelves the pleaſure of tranſcribing them.

" At page 54 of the pamphlet, we meet (ſays the reviewer) with a ſtrong proof of the confidence placed in this remedy by ſeveral tranſatlantic philoſophers. Dr Willard, it ſeems, applied a red-hot piece of iron to a wart on his finger, and burnt himſelf very ſeverely, in order that he might be relieved by the tractors; which are ſaid to have given him eaſe in two ſucceſſive experiments. The author adds, 'many have ſubmitted to ſimilar meaſures, in order to *experience* the effects. I once formed one of five, who burned ourſelves ſo that bliſters were raiſed, to make the experiment; we all obtained relief in a few minutes.'

" This zeal for knowledge is truly edifying; eſpecially as the tractors are generouſly preſented to the public at *only* five guineas a pair; and it is clear that one pair would ſuffice to cure all the burns and ſcalds of a large pariſh. Why are not ſuch luculent experiments repeated here? If Mr Perkins, or any admirer of the diſcovery, would ſubmit to have a red hot poker run into ſome part of his body not neceſſary to life (into *that part where honour's lodged*, according to Butler, for example), in any public coffee-houſe within the bills of mortality, and would afterward heal the wound in preſence of the company, in ten minutes, or in half as many hours, by means of the tractors, the moſt ſtony-hearted infidel could not reſiſt ſuch a demonſtration. Why trifle with internal inflammations, when ſuch an outward and viſible ſign might be afforded?

" Mr Perkins has taken ſome pains, in the firſt part of his pamphlet, to ſhew that the operation of his rods is not derived from animal magnetiſm. In our opinion, this is an unneceſſary piece of trouble in England, where there is a conſtant ſucceſſion of ſimilar pretenſions. The *virgula divinatoria*, and the *baguette* of the juggler, are the genuine prototypes of this myſtery. We were, indeed, rejoiced, on Dr Perkins's account, to find that the Connecticut Society had only denounced him as a Meſmeriſt: we trembled leſt he ſhould have been put into the inquiſitorial hands of the old women as a white witch."

This may be thought too ludicrous a treatment of a diſcovery which profeſſes to benefit mankind; but to have treated this diſcovery with ſeriouſneſs, would have degraded the profeſſion of a ſcientific critic. As if the very cures pretended to have been performed did not of themſelves throw ſufficient ridicule over the diſcovery, Mr Perkins informs us, " that in ſome inſtances the metallic influence, when excited by different perſons, produces different effects. Experiments made to aſcertain the point, proved that there were perſons who might uſe the tractors for any length of time, in diſeaſes which were ſuitable for the operation, and produce no perceptible effect; when by placing them in the hands of another perſon, who ſhould perform the operation preciſely in the ſame manner as before, the pain or inflammation would be removed directly." Hence he endeavours to prove that the influence of the tractors is Galvanic, by an argument as abſurd as the pretended fact on which it is founded.

" On the application (ſays he) of zinc and ſilver to the tongue, the ſenſation of taſte is very ſlight to ſome, while with others it is very ſtrong:—when the experiment is applied to the ſenſe of ſight, ſome are hardly ſenſible of it, while others obſerve a ſtrong flaſh." But, not to mention that neither ebony nor ivory can form part of the excitatory arc in *Galvaniſm*, though we have ſeen them both employed *ſucceſsfully* as tractors by a Daniſh Perkiniſt, it is enough to obſerve, that the different effects of the Galvanic metals on different perſons depend upon the difference of ſtructure of the organs of ſenſation in the *patients ;* whereas the different effects of the metallic tractors reſult, according to this account, from the difference of ſtructure in the organs of ſenſe of the various *operators !* Nay, what is ſtill more extraordinary, if any thing can be more extraordinary than this, is, that the value of the tractors depends, not upon the *materials* of which they are made, or the *ſkill* of the manufacturer, but upon ſome inconceivable virtue conveyed by Mr Perkins to the *perſon* of him by whom they are *ſold.* This we learn from a pamphlet publiſhed by Charles Cunningham Longworthy, ſurgeon in Bath ; who informs us, that he ſells tractors by *commiſſion* from Mr Perkins the original manufacturer in London."

After this article was ſent to the preſs, and thus much of it printed, we received, from a friend in London, a copy of Mr Perkins's laſt publication on the ſubject *; in which he endeavours to repel the objections urged by Dr Haygarth and others againſt the influence of the metallic tractors. Had we not been previouſly convinced of the falſity of Perkiniſm, the peruſal of this pamphlet would have removed from our minds every doubt ; for we will venture to ſay, that it is not in the power of Dr Haygarth, and the whole faculty united, to bring more complete proof than Mr Perkins has here brought, that what he calls his father's *diſcovery* has no claim to rank otherwiſe than with the diſcovery of Meſmer. See *Animal* MAGNETISM, Encycl.

He gives indeed 250 caſes, which are atteſted to have been ſucceſsfully treated by the tractors ; but at leaſt an equal number of caſes were atteſted to have been ſucceſsfully treated by Meſmer and his partiſans ; and ſix times that number of cures were ſaid to have been miraculouſly performed at the tomb of the Abbé Paris (See PARIS in this *Suppl.*) We would willingly allow, however, that theſe atteſtations ought to draw the attention of men of ſcience to the ſubject, did not the author himſelf betray a want of confidence in the tractors, by his own arguments in their favour, and by his caution to the public againſt *counterfeits.* He ſeems indeed to conſider their ſanative influence as reſulting entirely from his *patent.*

Dr Haygarth having ſaid that he performed cures of the ſame kind with thoſe of which Mr Perkins boaſts, by the proper application of tractors made of *wood ;* and having added, that "if any perſon would repeat theſe experiments, it ſhould be done with due ſolemnity," in order to work upon the imagination ; our author replies, by putting the following queſtion: "Is there a ſingle poſſeſſor of the *patent metallic* tractors in England, who has frequently uſed them, and will ſay that this fraud is neceſſary to make *them* perform *cures ?*" Inſtead of anſwering for the Engliſh poſſeſſors of theſe valuable inſtruments, we beg leave, in our turn, to aſk, if there be a ſingle expert chemiſt in Great Britain who can underſtand this queſtion in any other ſenſe, than as implying that the virtue of the tractors reſides in the *patent ?* This, however, appears ſtill more palpable in the caution to the public.

"Among the various artifices (ſays Mr Perkins) which have been employed by certain intereſted perſons, I have to mention the mean attempt to circulate *falſe tractors*, and from the failure of theſe to throw diſcredit upon the diſcovery. Three inſtances of this kind have occurred lately. Complaints having been made to me that my tractors would not cure the diſeaſes for which they are recommended, I was led to make inquiry reſpecting the caſes alluded to ; and conceiving them fit ſubjects for the tractors, I called on the patients to apply them myſelf. In *both* inſtances (it was juſt now in *three* inſtances) I found they had been uſing *counterfeit* tractors. Had not this been diſcovered, the *merit* of the *patent* tractors muſt have ſuffered extremely !"

This is very extraordinary. The *character* or *fame* of any thing may indeed be injured by a counterfeit ; but we believe this is the firſt inſtance of the *merit* or *demerit* of one inanimate ſubſtance being increaſed or diminiſhed by another at a diſtance from it,—of the hardneſs of ſteel, for inſtance, being diminiſhed by the ſoftneſs of lead ! But we beg Mr Perkins's pardon. The *merit* of his tractors conſiſts in their putting money into his pocket ; and *that* merit might certainly be injured by the uſe of *counterfeits.* Hence, with great propriety, he informs the public, that every *genuine ſet* is ſtamped with the words PERKINS'S PATENT TRACTORS, accompanied with a receipt for the five guineas, numbered and ſigned in the handwriting of the patentee. From theſe facts we infer (and he muſt acknowledge the inference to be juſt), that the virtue of the tractors reſides in the *patent*, reſtricting the making of them to *Benjamin Douglas Perkins*, and not to the *metal* of which they are made. This is indeed moſt obvious ; for he cannot be ſuch a ſtranger to the ſtate of chemical ſcience in this country, as to ſuppoſe that his tractors may not be analyſed into their component principles, and, of courſe, that others may not be made poſſeſſing all their virtues except ſuch as reſult from the patent.

We ſhall conclude this article in the words of the reviewer already quoted : "To trace the relations and dependencies of projects ſimilar to that of Dr Perkins, would now be a work of more labour than utility. The fund of public credulity is an inexhauſtible reſource for thoſe who can reſolve to levy contributions on it. In vain is the ſpirit of quackery exorciſed in one form ; it riſes again immediately, 'with twenty ghaſtly murders on its head, to puſh us from our ſtools.' We, who have contemplated the progreſs of real knowledge during a long courſe of years, have ſeen many bubbles like this glitter for a moment, and then diſappear for ever. People may talk of Meſmeriſm, or Perkiniſm, but we conſider all ſuch varieties as belonging to the old and extenſive claſs of Charlataniſm."

PEROUSE (John Francis Galoup de la), the celebrated, though unfortunate, French navigator, was born at Albi in 1741. Of the rank or condition of his father, M. *Milet-Mureau* has given us no information in that meagre eulogy of Perouſe which he has inſerted in the introduction to his laſt voyage. It appears, however, that he intended to make his ſon a ſeaman, and ſent him, at a very early period of life, to the marine ſchool, where the young man became enthuſiaſtically fond of his profeſſion, and laudably ambitious to emulate the fame of the moſt celebrated navigators.

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* *The Efficacy of Perkins's Patent Metallic Tractors, &c.* 1800.

Being appointed a midſhipman on the 19th of November 1756, he behaved, we are told, with great bravery in that ſtation, and was ſeverely wounded in the engagement between the admirals Hawke and Conflans, on the 20th of November 1759. The Formidable, in which he ſerved, was taken, after a vigorous reſiſtance; and it is probable that Perouſe reaped ſome advantage from his acquaintance with Britiſh officers.

On the 1ſt of October 1764 he was promoted to the rank of lieutenant; and deſpiſing a life of eaſe and idleneſs, he contrived to be employed in ſix different ſhips of war during the peace that ſubſiſted between Great Britain and France. In 1767 he was promoted to the rank of what, in our navy, is called *maſter* and *commander*. In 1779 he commanded the *Amazone*, belonging to the ſquadron of Vice-admiral Count d'Eſtaing; and when that officer engaged Admiral Byron, the poſt of La Perouſe was to carry his Admiral's orders to the whole of the line. He afterwards took the ſloop *Ariel*, and contributed to the capture of the *Experiment*—exploits which his eulogiſt ſeems to conſider as inſtances of very uncommon heroiſm; but he ſoon after performed a greater.

Being, on the 4th of April 1780, appointed captain of the frigate *Aſtrea*, and being on a cruiſe with the *Hermione*, theſe two frigates attacked ſix Engliſh veſſels of war, of from 28 to 14 guns each, and took two of them. The French certainly reaped more laurels about that period than they have been accuſtomed to do in naval wars with Great Britain; but as we have completely forgotten the particulars of this fight, we ſuſpect that it was not altogether ſo very brilliant a buſineſs as M. Milet-Mureau is pleaſed to repreſent it.

In the year 1782, La Perouſe was diſpatched with the Sceptre of 74 guns, and two frigates of 36 guns each, having ſome troops and field pieces on board, to deſtroy the Engliſh ſettlements in Hudſon's Bay. This taſk was eaſily accompliſhed; for when he had ſurmounted the difficulties of navigation in a frozen ſea, he found nothing on ſhore to oppoſe the ſmalleſt force. Having deſtroyed the ſettlements, he learned that ſome of the Engliſh had fled at his approach into the woods; and his eulogiſt conſiders it (ſuch are the diſpoſitions of French republicans) as a moſt wonderful inſtance of humanity, that he left to theſe unfortunate men proviſions to preſerve them from periſhing by hunger, and arms to protect them from the fury of the ſavages! Perouſe, we dare anſwer for him, was conſcious of nothing heroic or extraordinary in this act of beneficence, which he certainly could not have omitted, without incurring both infamy and guilt.

In the year 1785, he was appointed to the command of a voyage round the world; which was unfortunately deſtined to be his laſt. Of this voyage, as far as it was accompliſhed, there is a full account in the hands of every French and Engliſh reader; and from that account it appears, that Perouſe was admirably qualified to diſcharge ſuch a truſt. He ſeems to have been an experienced and ſkilful ſeaman; a man of conſiderable mathematical and phyſical ſcience, uncorrupted by that philoſophiſm which diſgraced many of his attendants; and capable of the utmoſt perſeverance in every laudable purſuit. To theſe qualities he united a proper combination of caution and courage, with a diſpoſition truly benevolent to the various tribes of ſavages whom he viſited. The diſaſters which occurred on the voyage were all, except the laſt, of which nothing is known, occaſioned by the diſobedience of his officers, or their neglecting to follow his advice.

The laſt diſpatches of this great and good man were dated from Botany Bay, February the 7th 1788; and ſince that period, no account of him has been received which is intitled to the ſmalleſt confidence. *M. Milet-Mureau* has indeed given us, at ſome length, the childiſh conjectures of the Society of Natural Hiſtory reſpecting his fate, which, in language equally childiſh, were delivered at the bar of the National Aſſembly; and he has added the ridiculous decree which that body of legiſlative ſcioliſts paſſed in conſequence of ſo extraordinary a ſpeech. We will not diſgrace our pages, or inſult the memory of Perouſe, by contributing to the circulation of nonſenſe, which, we are perſuaded, would have made him bluſh for his country.

PERPENDICULAR, in gunnery, is a ſmall inſtrument, uſed for finding the centre line of a piece in the operation of pointing it to a given object.

PERSIAN or PERSIC, in architecture, a name common to all ſtatues of men, ſerving inſtead of columns to ſupport entablatures.

PERWANNAH, in the language of Bengal, an order of government, or a letter from a perſon in authority.

PETERSBURGH (St), the capital of Ruſſia, is a city, of which a pretty full hiſtorical detail has been given in the *Encyclopædia*. It is introduced here merely on account of its police, which, according to the anonymous author of the life of Catharine II. has a very ſimple and competent organization, and deſerves to be adopted in other great capitals. Excepting the governor, whoſe office naturally extends to all objects of public welfare, the head police-maſter is the proper chief of the whole ſyſtem of police. His office takes in the great compaſs of this department, but confined to the general objects of public ſecurity and order. He is not here, as in ſome large towns, the formidable copartner of family ſecrets, and the inviſible witneſs of the actions of the private man. Under the head police-maſter is the police office, where ſit a police-maſter, two preſidents, the one for criminal, the other for civil caſes, and two conſulters, choſen from the burgher claſs. To this is committed the care to maintain decorum, good order, and morals: alſo it is its buſineſs to ſee to the obſervance of the laws, that the orders iſſued by government, and the deciſions of the courts of juſtice, are put in force. The attainment of theſe purpoſes is effected by the following mechaniſm:

The reſidence is divided into ten departments. Each of theſe has a preſident, appointed to watch over the laws, the ſecurity, and the order of his diſtrict. The duties and rights of this office are not leſs extenſive than important. A preſident muſt have exact knowledge of the inhabitants of his department, over which a ſort of parental authority is committed to him; he is the *cenſor morum* of his department; his houſe muſt not be bolted or barred by night or day, but muſt be a place of refuge, continually open to all that are in danger or diſtreſs; he himſelf may not quit the town for the ſpace of two hours, without committing the diſcharge of his office to ſome other perſon. The police commando (conſtables), and the watchmen of his department, are under his orders; and he is attended on all affairs of his office by two ſerjeants. Complaints againſt unjuſt behaviour in the preſident may be brought to the police office.

Each department is again divided into three, four, or five ſubdiviſions, called quarters, of which, in the whole reſidence, are 42. Each of theſe has a quarter-inſpector, in ſubordination to whom is a quarter-lieutenant. The duty of theſe police-officers is in harmony with that of the preſident, only that their activity is confined to a ſmaller circle. They ſettle low affairs and ſlight altercations on the ſpot, and keep a watchful eye on all that paſſes.

The number of the nightly watch in the city amounts to 500. They have their ſtations aſſigned them in watch-houſes at the corners of ſtreets; and, beſides their proper deſtination, are to aſſiſt in the taking up of offenders, and in any ſervice, by day or night, as their commanders ſhall require. Beſides theſe, for the execution of the police orders, and to act as patroles, there is alſo a commando of 120 men, who, in caſes of emergency, are ſupported by a company of koſaks, or a regiment of huſſars.

This machine, conſiſting of ſo many ſubordinate parts, preſerves in its orderly courſe that ſecurity and peace which excite the admiration of all foreigners. The activity of every individual member is unobſerved in the operation of the whole; and by ſuch a diſtribution alone is the attainment of ſo complicated an aim practicable.—All the quarter-inſpectors of a department repair every morning, at ſeven o'clock, to their inſpector's houſe, to lay before him the report of all that has happened in their quarters during the laſt 24 hours; and at eight o'clock, all the inſpectors bring together theſe ſeveral reports into the police-office, whereupon they firſt and immediately take into examination the caſes of perſons taken into cuſtody during the night. On urgent occaſions, the police-office aſſembles at all hours.

This organization, and the extraordinary vigilance of the police, which is found competent to the buſineſs of a numerous and reſtleſs people, render all ſecret inquiſitions unneceſſary. The police has knowledge of all perſons in the reſidence; travellers who come and go are ſubject to certain formalities, which render it extremely difficult to conceal their place of abode, or their departure from the city. To this end, every houſeholder and innkeeper is obliged to declare to the police, who lodges with him, or what ſtrangers have put up at his houſe. If a ſtranger or lodger ſtays out all night, the landlord muſt inform the police of it at lateſt on the third day of his abſence from his houſe. The cautionary rules, in regard to travellers quitting the town, are ſtill more ſtrict. Theſe muſt publiſh in the newſpapers their name, their quality, and their place of abode, three ſeveral times, and produce the newſpapers containing the advertiſement, as a credential in the government from which they then receive their paſſport; without which, it is next to impoſſible to get out of the empire. This regulation not only ſecures the creditor of the perſon about to depart, but alſo enables the police to keep a cloſer inſpection over all ſuſpected inhabitants.

If individuals may be ſuſpected by the government, becauſe their means of ſupport, the company they keep, and their whole courſe of action, are cloſely wrapped up in myſtery; ſo likewiſe may whole ſocieties be leſs indifferent to it, if they carefully conceal the object of their connection, or their very exiſtence, from the eye of the public. The police watches here, with laudable attention, over ſecret ſocieties of all kinds; and frequently as the fanatical ſpirit of religious or political ſectaries, or the enthuſiaſm of pretended myſtagogues, have attempted to neſtle here, they have never been able to proceed, or only for a very ſhort time. Animal magnetiſm, Martiniſm, Roſycrutianiſm, and by whatever other name the conceits of diſtempered imaginations may be called, have always been attended with the ſame bad ſucceſs on this ſtage.

From this ſketch it will be readily imagined, that the number of impoſtors and diſturbers of the public peace can be but ſmall. Quarrels and affrays in the ſtreet or in the cabaks but ſeldom happen. The perſon attacked calls the neareſt watchman; and in a moment both the aggreſſor and the aggrieved are taken into cuſtody, and led to the next ſieja (police-watch-houſe), where the cauſe of their quarrel is inquired into, and the aggreſſor is puniſhed. For matters of ſome deſcriptions, there is a peculiar tribunal, under the denomination of the oral court, which, on account of its ſingularity, deſerves to be briefly noticed.

In each quarter of the town are one or more judges of the oral court, who are choſen from the claſs of burghers, and with whom are aſſociated a few jurats. This court ſits daily in the forenoon, and proceeds orally in all the differences that come before it. It, however, keeps a day-book, in which are entered all the cauſes and deciſions of the court, and which muſt be every week laid before the magiſtrate. When a charge is brought, the court declares it orally to the preſident of the quarter: whereupon the accuſed muſt not delay his appearance before the police longer than one day after he has received the ſummons. Every cauſe muſt be determined in one day, or, if the examinations require more time in collecting, in three days. The oral court communicates the deciſion to the preſident of the quarter by means of his day-book, in order to its ratification. If either party is not ſatisfied with the ſentence, he may appeal to the court as appointed in the regulations.

This is a very favourable account of the police of St Peterſburgh; but it is differently repreſented in *Beaujolin's Travels of two Frenchmen through Ruſſia*, in 1790—1792. According to him, the police of the capital of that empire is far from being on the moſt reſpectable footing. There happen, indeed, but few accidents in the night; yet ſometimes murders are committed, and eſpecially thefts; for which, according to our author, it is exceedingly rare to obtain juſtice. When a perſon has been aſſaſſinated in ſome place of bad repute, the police-officer is engaged to ſecrecy by means of a few rubles; ſo that the affair is ſoon huſhed up, unleſs the deceaſed belonged to ſome powerful family, whoſe intereſt makes it neceſſary that inquiries ſhould be inſtituted. When two perſons quarrel, either in the ſtreet or in a public-houſe, he who *pays* the inquirer is always in the right: the inferior police-officers are never proof againſt money; and the *poor* individual, whether he be in the right or wrong, is almoſt ſure of a beating.

PETIVER (James), a famous Engliſh botaniſt, was contemporary with Plukenet; but the exact time of his birth is not known, nor is much intelligence concerning him at preſent to be obtained. His profeſſion was that of an apothecary, to which he was apprenticed under Mr Feltham, then apothecary to St Bartholomew's hoſpital *. When he entered into buſineſs for himſelf, he ſettled in Alderſgate-ſtreet, and there continued for the remainder of his life. He obtained conſiderable buſineſs, and after a time became apothecary to the charter-houſe. After the Tradeſcants, he appears to have been the only perſon, except Mr Courten and Sir Hans Sloane, who made any conſiderable collection in natural hiſtory, previous to thoſe of the preſent day. He engaged the captains and ſurgeons of ſhips to bring him home ſpecimens, and enabled them to ſelect proper objects, by printed directions which he diſtributed among them. By theſe means his collection became ſo valuable, that ſome time before his death, Sir Hans Sloane offered him L. 4000 for it. After his death, it was purchaſed by the ſome collector. His muſeum extended his fame both at home and abroad. He was elected into the Royal Society; and becoming acquainted with Ray, aſſiſted him in arranging the ſecond volume of his Hiſtory of Plants. He died April 20. 1718; and much honour was ſhewn to him at his funeral, by the attendance of Sir Hans Sloane, and other eminent men, as pall bearers, &c. By future botaniſts, his name was given to a plant. See PETIVERIA, *Encycl.*

He gave the world ſeveral publications on various ſubjects of natural hiſtory: 1. *Muſei Petiveriani Centuriæ decem*, 1692—1703, 8vo. 2. *Gazophylacii Naturæ et Artis, Decades decem*, folio, 1702, with 100 plates. 3. A Catalogue of Mr Ray's Engliſh Herbal, illuſtrated with figures, folio, 1713, and continued in 1715. 4. Many ſmall publications, which may be found enumerated in Dr Pultney's book. 5. Many papers in the Philoſophical Tranſactions, and a material article in the third volume of Ray's work, entitled, *Plantæ Rariores Chinenſes Madraſpatanæ, et Africanæ, a Jacobo Petivero ad opus Conſummandum Collatæ*, &c. Many of his ſmaller tracts having become very ſcarce, his works were collected and publiſhed, excluſive of his papers in the Tranſactions, in 2 vols folio, and one 8vo, in the year 1764.

PHASIANUS (See *Encycl.*). A ſpecies of this genus of birds, formerly not deſcribed, was ſent from Batavia to England by Lord Macartney, or ſome of his attendants, when they were on their voyage to China. The ſpecies to which it ſeemed to be moſt nearly allied, in point of general habit or appearance, was the *phaſianus curviroſtris*, or Impeyan pheaſant; an Eaſt Indian bird, deſcribed and figured both in Mr Latham's Ornithology, and in the Muſeum Leverianum. From that bird, however, it differs very conſiderably. The tail of the latter being in a mutilated ſtate, it was ſcarce poſſible to determine, with abſolute preciſion, whether it ſhould be referred to that ſubdiviſion of pheaſants, which contains thoſe with long or cuneiform tails, or thoſe with rounded ones, as in the Impeyan pheaſant. The general colour of this moſt elegant bird was black, with a gloſs of blue, or what, in the language of natural hiſtory, may be termed chalybean black, or black accompanied by a ſteel blue luſtre. The lower part of the back was of a peculiarly rich colour, which, according to the different directions of the light, appeared either of a deep ferruginous or of the brighteſt fiery orange-red. This beautiful colour paſſed in the manner of a broad zone round the whole body; but on the abdomen was of a much more obſcure appearance than on the back, as well as ſomewhat broken or irregular, eſpecially on the ſides. The throat was furniſhed with a large, and ſomewhat angular, pair of wattles, uniting with the bare ſpaces on the cheeks. The feathers on the top of the head, which was of a lengthened form, ran a little backward, ſo as to give the appearance of an indiſtinct occipital creſt. The beak was remarkable for a more lengthened and curved aſpect than in any other bird of this genus, except the Impeyan pheaſant. The feathers on the neck, back, and breaſt, were rounded, and of the ſame ſhell-like or ſcaly habit as thoſe of the turkey. The legs very ſtout, and were armed with a pair of extremely ſtrong, large, and ſharp ſpurs. Both legs and beak were of a pale colour. Whether this bird be really new or not to the ornithologiſts of Europe, it may at leaſt be affirmed with ſafety, that it had never been properly deſcribed; nor can the character of any ſpecies, hitherto introduced into the books of any ſyſtematic naturaliſt, be conſidered as a juſt or competent ſpecific character of the preſent bird. It may be called the *fire-backed pheaſant*; and its eſſential character may be delineated in the following terms: Black pheaſant with a ſteel-blue gloſs; the ſides of the body rufous; the lower part of the back fiery ferruginous; the tail rounded; the two middle feathers pale yellow brown.—*Sir George Staunton's Account of an Embaſſy to China, &c.*

PHILOSOPHIST, a lover of ſophiſtry or falſe reaſoning, in contradiſtinction to *philoſopher*, who is a lover of ſound reaſoning, true ſcience, and practical wiſdom.

CRITICAL PHILOSOPHY.

1 Origin of the ſcience.

CRITICAL PHILOSOPHY, is the appellation given to a ſyſtem of ſcience, of which the founder is *Immanuel Kant*, regius profeſſor of logic and metaphyſics in the univerſity of Koenigſberg. Of this ſyſtem, which is very generally admired in Germany, we promiſed, in our Proſpectus, to gratify our ſpeculative readers with a ſhort view; and that promiſe we are enabled to fulfil, by the kind communication of an illuſtrious foreigner, who, after acting a conſpicuous part on the theatre of the world, and ſtriving in vain to ſtem the torrent of democratic innovation, is now living an exile from his wretched country, and cultivating the ſciences and the arts of peace.

2 Obſcurity of its language.

"To explain (ſays he) the philoſophy of Kant in all its details, would require a long and a painful ſtudy, without producing any real advantage to the reader. The language of the author is equally obſcure, and his reaſonings equally ſubtle, with thoſe of the commentators of Ariſtotle in the 15th century."

The truth of this aſſertion will be denied by none, who have endeavoured to make themſelves maſters of the works of *Willich* and *Nitſch* on the critical philoſophy; and the ſource of this obſcurity ſeems to be ſufficiently obvious. Beſides employing a vaſt number of words of his own invention, derived from the Greek language, Kant uſes expreſſions, which have long been familiar to metaphyſicians, in a ſenſe different from that in which they are generally received; and hence a large portion of time is requiſite to enable the moſt ſagacious mind to aſcertain with preciſion the import of his phraſeology.

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* Pulteney's *Sketches of Botany in England.*

The difficulty of comprehending this philoſophy has contributed, we believe, more than any thing elſe, to bring it into vogue, and to raiſe the fame of its author. Men are aſhamed, after ſo laborious and fatiguing a ſtudy, to acknowledge that all their labour has been thrown away; and vanity prompts almoſt every man to raiſe the importance of that branch of ſcience which is underſtood but by a few, and in which he is conſcious that his own attainments have been great. "We acknowledge, however, that in the ſyſtem of Kant there is diſplayed much genius, combination, and ſyſtematic arrangement; but this only affords one of the many reaſons which it preſents, for our regretting that the author has not directed his mind to more uſeful reſearches, and that he has waſted the ſtrength of his genius in rendering uncertain the moſt comfortable truths, and in giving the appearance of novelty to opinions for the moſt part taught long before his day.

The following analyſis, we believe, will ſufficiently enable any one, at all converſant with metaphyſical ſcience, to form a judgment of this celebrated ſyſtem; and our correſpondent, on whoſe word the reader may rely, aſſures us, that, in detailing the principles of Kant, he has taken ſpecial care to exhibit them with the utmoſt poſſible exactneſs, having ſeveral times preferred the obſcurity of the author's reaſonings and language, to the danger of a falſe, though more perſpicuous, interpretation.

3 Diviſion of human knowledge. "Kant divides all our knowledge into that which is *a priori*, and that which is *a poſteriori*. Knowledge *a priori* is conferred upon us by our nature. Knowledge *a poſteriori* is derived from our ſenſations, or from experience; and is by our author denominated *empyric*. One would at firſt be induced, by this account of the origin of human knowledge, to believe that Kant intended to revive the ſyſtem of *innate ideas*; but we very quickly diſcover that ſuch is not his ſyſtem. He conſiders all our knowledge as acquired. He maintains, that experience is the *occaſional cauſe* or *productrice* of all our knowledge; and that without it we could not have a ſingle idea. Our ideas *a priori*, he ſays, are produced *with* experience, and could not be produced *without* it; but they are not produced *by* it, or do not proceed *from* it. They exiſt in the mind; they are the *forms* of the mind. They are diſtinguiſhed from other ideas by two marks, which are eaſily diſcerned; *i. e.* they appear *univerſal* and *neceſſary*; or, in other words, they admit of no exception, and their *converſe* is impoſſible. Ideas which we derive from experience have no ſuch characters. We can ſuppoſe, that what we have ſeen, or felt, or heard once, we may ſee, or feel, or hear again; but we do not perceive any impoſſibility in its being otherwiſe. For inſtance, a houſe is on fire in my view: I am certain of this fact; but it affords me no *general* or *neceſſary* knowledge. It is altogether *a poſteriori*; the materials are furniſhed by the individual impreſſion which I have received; and that impreſſion might have been very different.

"But if I take twice two ſmall balls, and learn to call twice two *four*, I ſhall be immediately convinced, that any two bodies whatever, when added to any two other bodies, will conſtantly make the ſum of bodies *four*. Experience has indeed afforded me the *opportunity* of acquiring this knowledge; but it has not given it to me; for how could experience prove to me that this truth ſhall never vary? Experience muſt always be *limited*; and therefore cannot teach us that which is *neceſſary* and *univerſal*. It is not experience which diſcovers to us, that we ſhall always have the ſurface of the whole pyramid by multiplying its baſe by the third part of its height; or that two parallel lines, extended *in infinitum*, ſhall never meet.

"All the truths of pure mathematics are, in the language of Kant, *a priori*. Thus, that a ſtraight line is the ſhorteſt of all poſſible lines between two fixed points; that the three angles of a triangle are always equal to two right angles; that we have the ſame ſum, whether we add 5 to 7 or 7 to 5; and that we have the ſame remainder when we ſubtract 5 from 10 as when we ſubtract 10 from 15—are ſo many propoſitions, which are true *a priori*.

4 Pure knowledge *a priori*. "Pure *knowledge a priori*, is that which is abſolutely without any mixture of experience. *Two and two men* make *four men*, is a truth, of which the knowledge is *a priori*; but it is not PURE knowledge, becauſe the truth is particular. The ideas of *ſubſtance*, and of *cauſe* and *effect*, are *a priori*; and when they are ſeparated from the objects to which they refer (we ſuppoſe from this or that *particular* object), they form, in the language of Kant, *void ideas* (A). It is our knowledge *a priori*, *i. e.* that knowledge which precedes experience as to its origin, which renders experience poſſible (B). Our faculty of knowledge has an effect on our ideas of ſenſation analogous to that of a veſſel, which gives its own form to the liquor with which it is filled. Thus, in all our knowledge *a poſteriori*, there is ſomething *a priori* derived from our faculty of knowledge. All the operations of our minds; all the impreſſions which our external and internal ſenſes receive and retain, are brought into effect by the *conditions*, the *forms*, which exiſt in us by the pure ideas *a priori*, which alone render all our other knowledge certain.

5 Time and ſpace. "*Time* and *ſpace* are the two eſſential forms of the mind:

(A) In the language of Locke *abſtract ideas*.

(B) In our correſpondent's manuſcript, this ſentence runs thus: "It is our knowledge *a priori*, or that knowledge which *entirely precedes experience* as to its origin, which experience renders poſſible;" but here muſt be ſome miſtake, either by the tranſlator or by the amanuenſis. Kant's philoſophy is abundantly obſcure and paradoxical; but it ſurely never entered into his head to repreſent the effect as prior in its origin to the very cauſe which alone renders it poſſible. The context, too, ſeems to us to agree better with the meaning of the ſentence as we have printed it in the text.

mind : the former for impreſſions received by the internal ſenſe ; the ſecond for thoſe received by our external ſenſes. Time is neceſſary in all the *immediate* (perhaps *intuitive*) perceptions of objects ; and ſpace in all *external* perceptions.

6 Extenſion.

" *Extenſion* is nothing real but as the form of our ſenſations. If extenſion were known to us only by experience, it would then be poſſible to conceive that there might be ſenſible objects without ſpace.

7 Impenetrability, &c

" It is by means of the form *ſpace* that we are enabled, *a priori*, to attribute to external objects *impenetrability*, *diviſibility*, *mobility*, &c. ; and it is by means of the form *time* that we attribute to any thing *duration*, *ſucceſſion*, *ſimultaneity*, *permanence*, &c.

8 Origin of arithmetic and geometry.

" *Arithmetic* is derived from the form of our internal ſenſe, and *geometry* from that of our external.

9 Unifying power of the mind.

" Our underſtanding collects the ideas received by the impreſſions made on our organs of ſenſe, confers on theſe ideas *unity* by a particular *force* (we ſuppoſe energy) *a priori* ; and thereby forms the repreſentation of each object. Thus, a man is ſucceſſively ſtruck with the impreſſions of all the parts which form a particular garden. His underſtanding unites theſe impreſſions, or the ideas reſulting from them ; and in the unity produced by that unifying act, it acquires the idea of the garden. If the objects which produce the impreſſions afford alſo the *matter* of the ideas (c), then the ideas are *empyric* ; but if the objects only unfold the *forms of the thought*, the ideas are *a priori*. The act of the underſtanding which unites the perceptions of the various parts of an object into the perception of one whole, is the ſame with that which unites the attribute with its ſubject.

10 Analytic judgments.

" Judgments are divided into two ſpecies ; *analytic* and *ſynthetic*. An analytic judgment is that in which the attribute is the mere developement of the ſubject, and is found by the ſimple analyſis of the perception ; as *bodies are extended* ; *a triangle has three ſides*.

11 Synthetic judgments.

" A ſynthetical judgment is that where the attribute is connected with the ſubject by a cauſe (or baſis) taken from the faculty of knowledge, which renders this connection neceſſary : as, *a body is heavy* ; *wood is combuſtible* ; *the three angles of a triangle are equal to two right angles*. There are ſyntheſes *a priori* and *a poſteriori* ; and the former being formed by experience, we have the ſure means of avoiding deception.

" It is a problem, however, of the utmoſt importance, to diſcover how ſynthetic judgments *a priori* are poſſible. How comes it, for example, that we can affirm that all the radii of a circle are equal, and that two parallel lines will never meet ? It is by ſtudying the *forms* of our mind that we diſcover the poſſibility of making theſe affirmations. In all objects there are things which muſt neceſſarily be THOUGHT (be ſupplied by thought) ; as, for example, that there is *a ſubſtance*, an *accident*, a *cauſe*, and certain *effects*.

12 Forms of the underſtanding.

" The *forms* of the underſtanding are, *quantity*, *quality*, *relation*, *modality*.

" Quantity, Kant diſtinguiſhes into *general*, *particular*, and *individual* ; quality, into *affirmation*, *negation*, *infinite* ; relation, into *categoric*, *hypothetic*, and *disjunctive* ; and modality, into *problematic*, *certain*, and *neceſſary*. He adds alſo to theſe properties of the four principal forms of the underſtanding, a table of *categories*, or fundamental ideas *a priori*.

13 Categories.

" Quantity, gives *unity*, *plurality*, *totality*. Quality, gives *reality*, *negation*, *limitation*. Relation, gives *inherence*, *ſubſtance*, *cauſe*, *dependence*, *community*, *reciprocity*. Modality, gives *poſſibility*, *impoſſibility*, *exiſtence*, *nothing*, *neceſſity*, *accident*. Theſe categories can only be applied to experience. When, in the conſideration of an object, we abſtract all that regards ſenſation, there remain only the pure ideas of the underſtanding, or the *categories*, by which a *thing* is conceived as a *thing*.

" Pure reaſon is the faculty of tracing our knowledge *a priori*, to ſubject it to principles, to trace it from its neceſſary conditions, till it be entirely without condition, and in complete unity. This pure reaſon has certain fundamental rules, after which the neceſſary connection of our ideas is taken for the determination of the objects in themſelves ;—an illuſion which we cannot avoid, even when we are acquainted with it. We can conclude from what we know to what we do not know ; and we give an *objective* reality to theſe concluſions from *an appearance* which leads us on.

14 Critique of pure reaſon.

" The writings of Kant are multifarious ; but it is in his work entitled the *Critique of Pure Reaſon* that he has chiefly expounded his ſyſtem. This work is a treatiſe on a pretended ſcience, of which Kant's ſcholars conſider him as the founder, and which has for its objects the *natural forces*, the *limits of our reaſon*, as the ſource of our pure knowledge *a priori*, the *principles of all truth*. Kant does not propoſe to give even an expoſition of theſe branches of knowledge, but merely to examine their origin ; not to extend them, but to prevent the bad uſe of them, and to guard us againſt error. He denominates this ſcience *tranſcendental criticiſm* ; becauſe he calls all knowledge, of which the object is not furniſhed by the ſenſes, and which concerns the kind and origin of our ideas, *tranſcendental knowledge*. The Criticiſm of Pure Reaſon, which gives only the fundamental ideas and maxims *a priori*, without explaining the ideas which are derived from them, can lead (ſays Kant) to a complete ſyſtem of pure knowledge, which ought to be denominated *tranſcendental philoſophy*, of which it (the *Criticiſm*, &c.) preſents the *architectonic* plan, *i. e.* the plan regular and well diſpoſed.

" The work entitled *The Critique of Pure Reaſon*, is divided into ſeveral parts or ſections, under the ridiculous titles of *Æſthetic tranſcendental* ; of *tranſcendental logic* ; of *the pure ideas of the underſtanding* ; of *the tranſcendental judgment* ; of *the paralogiſm of pure reaſon* ; of *the ideal tranſcendental* ; of *the criticiſm of ſpeculative theologies* ; of *the diſcipline of pure reaſon*, &c.

15 We cannot know objects as they are in themſelves.

" But to proceed with our abſtract of the ſyſtem. We know objects only by the manner in which they affect us ; and as the impreſſions which they make upon us are only certain *apparitions* or *phenomena*, it is impoſſible for us to know what an *object is in itſelf*. In conſequence of this aſſertion, ſome have ſuppoſed that Kant is an *idealiſt* like Berkeley and ſo many others, who have thought that ſenſations are only *appearances*, and

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(c) This is wonderful jargon ; but the reader will reflect that it is not ours.

and that there is no truth but in our reaſon; but ſuch is not the opinion of Kant (D). According to him, our underſtanding, when it conſiders the apparitions or phenomena, acknowledges the *exiſtence* of the objects in themſelves, inaſmuch as they ſerve for the baſes of thoſe apparitions; though we know nothing of their *reality*, and though we can have no certitude but in experience.

" When we apply the *forms* of our underſtanding, ſuch as *unity*, *totality*, *ſubſtance*, *caſuality*, *exiſtence*, to certain ideas which have no object in *ſpace* and *time*, we make a fallacious and arbitrary application. All theſe forms can bear only on ſenſible objects, and not on the *world of things in itſelf*, of which we can THINK, but which we CAN NEVER KNOW. Beyond things ſenſible we can only have *opinions* or a *belief* of our reaſon.

16 Objective and ſubjective truths. " The motives to conſider a propoſition as true, are either *objective*, *i. e.* taken from an *external* object, ſo that each man ſhall be obliged to acknowledge them; and then there is a truth *evident* and ſuſceptible of *demonſtration*, and it may be ſaid that we are *convinced*; or the motives are *ſubjective*, *i. e.* they exiſt only in the mind of him who judges, and he is *perſuaded*.

" TRUTH, then, conſiſts in the agreement of our *notions* with the *objects*, in ſuch a manner as that all men are obliged to form the ſame judgment; BELIEF conſiſts in holding a thing for true in a *ſubjective manner*, in conſequence of a perſuaſion which is entirely perſonal, and has not its baſis in an object ſubmitted to experience.

1 Belief. " There is a *belief of doctrine*, of which Kant gives, as an example, this aſſertion—' there are inhabitants in the planets.' We muſt acknowledge (he adds) that the ordinary mode of teaching the exiſtence of God belongs to *the belief of doctrine*, and that it is the ſame with *the immortality of the ſoul*. *The belief of doctrine* (he continues) has in itſelf ſomething *ſtaggering*; but it is not the ſame with *moral belief*. In moral belief there is ſomething *neceſſary*; it is (ſays he), that I ſhould obey the law of morality in all its parts. The end is ſtrongly eſtabliſhed; and I can perceive only one condition, by means of which this end may be in accord with all the other ends, *i. e.* that *there is a God*. I am certain that no man knows any other condition which can conduct to the ſame unity of end under the moral law; which law is a law of my reaſon. I will conſequently believe certainly the *exiſtence of God*, and a *future life*; becauſe this perſuaſion renders immoveable my moral principles—principles which I cannot reject without

18 Proof of the exiſtence of God, &c. rendering myſelf contemptible in my own eyes. I wiſh for happineſs, but I do not wiſh for it without morality; and as it depends on *nature*, I cannot wiſh it with this condition, except by believing that nature depends on a Being who cauſes this connection between morality and happineſs. This ſuppoſition is founded on the *want* (or *neceſſity*) of my reaſon, and not on my duty.

" We have, however, no *certainty* (ſays Kant) in our knowledge of God, becauſe certainty cannot exiſt except when it is founded on an object of experience. The philoſopher acknowledges, that *pure reaſon* is too weak to prove the exiſtence of a being beyond the reach of our ſenſes. The neceſſity of believing in God is therefore only *ſubjective*, although neceſſary and general for all thoſe beings who conform to their duty. This is not *knowledge*, but only a *belief* of reaſon, which ſupplies the place of a knowledge which is impoſſible (E).

" The proofs of natural theology (ſays our philoſopher) taken from the order and beauty of the univerſe, &c. are proofs only in *appearance*. They reſolve themſelves into a bias of our reaſon to *ſuppoſe* an Infinite Intelligence as the author of all that is poſſible; but from this bias it does not follow that there really is ſuch an Author. To ſay, that whatever exiſts muſt have a cauſe, is indeed a maxim *a priori*; but it is a maxim applicable only to experience, for one knows not how to ſubject to the laws of our perceptions that which is abſolutely independent of them. It is as if we were to ſay, that whatever exiſts in experience muſt have an experience; but the world, taken as a whole, is without experience as well as its cauſe. It is much better to draw the proof of the exiſtence of God from morality, than to weaken it by ſuch reaſoning. This proof is relative. It is impoſſible to *know* that God exiſts; but we can comprehend how it is poſſible to act morally on the *ſuppoſition* of the exiſtence (although incomprehenſible) of an intelligent Creator—an exiſtence which PRACTICAL REASON forces THEORETICAL *reaſon* to adopt. This proof not only *perſuades*, but even acts on the CONVICTION, in proportion as the motives of our actions are conformable to the law of morality.

" Religion ought to be the *means* of virtue and not its object. Man has not in himſelf the idea of religion as he has that of virtue. The latter has its principle in the mind; it exiſts in itſelf, and not as the means of happineſs; and it may be taught without the idea of a God, for the pure law of morality is *a priori*.

" He who does good by inclination does not act *morally*. The converſe of the principle of morality is to make perſonal happineſs the baſis (F) of the will. There are compaſſionate minds which feel an internal pleaſure in communicating joy around them, and who thus enjoy the ſatiſfaction of others; but their actions, however juſt, however good, have no moral merit, and may be compared to other inclinations; to that of 19 Morality.

honour

(D) We muſt requeſt the reader to obſerve that this is the language of our correſpondent. We have ſhewn elſewhere, that Berkeley did not deny the reality of ſenſations; and we hope to ſhew by and bye, that Kant is as much an *idealiſt* as he was, if this be a fair view of the Critical Philoſophy.

(E) We have here again taken the liberty to alter the language of our correſpondent. He makes Kant ſay, " It is not this knowledge, but a *belief* of reaſon, &c.;" but this is ſurely not the author's meaning. From the context, it is apparent that Kant means to ſay, that we have not, and cannot have, what can be properly called a *knowledge* of the exiſtence of God, but only ſuch a belief of his exiſtence as ſupplies the place of this impoſſible knowledge.

(F) This is a very abſurd phraſe. We ſuppoſe Kant's meaning to be, that the principles of him whoſe actions and volitions are influenced by the proſpect of perſonal happineſs, are the reverſe of the pure principles of morality.

honour (for example), which, whilſt it meets with that which is juſt and uſeful, is worthy of praiſe and encouragement, but not of any high degree of eſteem. According to Kant, we ought not even to *do good*, either for the pleaſure we feel in doing it, or in order to be happy, or to render others happy; for any one of theſe additions (perhaps motives) would be *empyric*, and injure the purity of our morals. A reaſonable being ought to deſire to be exempted from all *inclinations*, and never to do his duty but for his duty's ſake.

" We ought to act after the maxims derived *a priori* from the faculty of knowledge, which carry with them the idea of neceſſity, and are independent of all experience; after the maxims which, it is to be wiſhed, could be erected into GENERAL LAWS for all beings endowed with reaſon."

20 Futility of this ſyſtem

If this be a correct view of the object and the reſults of the critical philoſophy, and the character of him from whom we received it permits us not to doubt of its being nearly correct, we confeſs ourſelves unable to diſcover any motive which ſhould induce our countrymen, in their reſearches after truth, to prefer the dark lantern of Kant to the luminous torch of Bacon. The metaphyſical reader will perceive, that, in this abſtract, there is little which is new except the phraſeology; and that what is new is either unintelligible or untenable.

21 Of which the fundamental principles are not new.

The diſtinction between knowledge *a priori* and knowledge *a poſteriori*, is as old as ſpeculation itſelf; and the mode in which Kant illuſtrates that diſtinction differs not from the illuſtrations of Ariſtotle on the ſame ſubject. The Stagyrite talked of *general forms*, or *formal cauſes*, in the mind, as well as the profeſſor at Koenigſberg; and he or his diſciples (for we quote from memory) compared them to the form of the ſtatue in the rough block of marble. As that form is brought into the view of the ſpectator by the chiſſel of the ſtatuary, ſo, ſaid the peripatetics, are the general *forms* in the mind brought into the view of conſciouſneſs by ſenſation and experience.

Such was the doctrine of Ariſtotle and his diſciples, and ſuch ſeems to be the doctrine of Kant and his followers; but it is either a falſe doctrine, or, if it be true, a doctrine fooliſhly expreſſed. A block of marble is capable of being cut into any form that the ſtatuary pleaſes; into the form of a man, a horſe, an ox, an aſs, a fiſh, or a ſerpent. Not one of theſe forms therefore can be inherent in it, or eſſential to it, in oppoſition to the reſt; and a general form, including all the animals under it, is inconceivable and impoſſible. In like manner, the human mind is capable of having the ideas of a circle, a triangle, a ſquare, of black, white, red, of four, ſweet, bitter, of the odour of a roſe, and the ſtench of a dunghill, of proportion, of muſical ſounds, and of a thouſand other things. None of theſe ideas therefore can be eſſential to the mind in oppoſition to the reſt; and every man, who is not an abſolute ſtranger to the operations of his own intellect, knows well that he cannot think of a thouſand things at once; or, to uſe the language of philoſophers, have in his mind a general idea, comprehending under it a thouſand things ſo diſcordant as colours and ſounds, figures, and ſmells. If therefore Kant means to affirm, with Plato, that, previous to all experience, there are *actually* in the mind *general forms*, or *general ideas*, to which ſenſation, or experience, gives an opportunity of coming into view, he affirms what all men of reflection know to be falſe. If he means only to affirm, what ſeems to have been the meaning of Ariſtotle, that particular ſenſations give occaſion to the intellect to form general ideas, he expreſſes himſelf indeed very ſtrangely; but his doctrine on this ſubject differs not eſſentially from that of Locke and Reid, and many other eminent metaphyſicians of modern times. Of abſtraction and general ideas we have given our own opinion elſewhere (See METAPHYSICS, *Encycl.* Part I. Chap. iv.), and ſhall not here reſume the ſubject.

22 Improper uſe of terms;

But when Kant ſays that his ideas *a priori* are *univerſal*, and *neceſſary*, and that their converſe is *impoſſible*, he ſeems by the word *idea* to mean what more accurate writers expreſs by the term *propoſition*. There are indeed two kinds of propoſitions, of which both may be true, though the one kind expreſſes neceſſary and univerſal truths, and the other ſuch truths as are contingent and particular. (See METAPHYSICS, *Encycl.* Part I. Chapter vii.) Propoſitions directly contrary to thoſe which expreſs particular and contingent truths may be eaſily conceived; whilſt ſuch as are contrary to neceſſary and univerſal truths are inconceivable and impoſſible; but we doubt whether *any idea*, in the proper ſenſe of the word, has a *contrary* or, as he expreſſes it, a *converſe*. *Nothing* is not contrary to *ſubſtance*, nor *black* contrary to *white*, nor *four* contrary to *ſweet*, nor an *inch* contrary to an *ell*. Nothing is the negation of ſubſtance, and black the negation of white; four is different from ſweet, and an inch is leſs than an ell; but between theſe different ideas we perceive no contradiction.

That Kant uſes the term *idea* inſtead of *propoſition*, or ſome word of ſimilar import, is farther evident from his inſtances of *the houſe on fire*, and the manner in which we learn that any two bodies added to any two other bodies will conſtantly make the ſum of *four bodies*. If it be his will to uſe the terms *a priori* and *a poſteriori* in the ſenſe in which other metaphyſicians uſe the terms *neceſſary* and *contingent*, we can make no other objection to his diſtinction between theſe two propoſitions, but that it is expreſſed in very improper language. The houſe might certainly be *on fire* or *not* on fire; but twice two bodies *muſt* always make the ſum of four bodies, and cannot poſſibly make any other ſum.

The truth of this laſt propoſition (he ſays) we cannot have learned from *experience*, becauſe experience, being always limited, cannot poſſibly teach us what is *neceſſary* and *univerſal*. But this is egregious trifling. The experience employed here is not limited A child unqueſtionably learns the import of the terms of numeration, as he learns the import of all other terms, by experience. By putting two little balls to two little balls, he learns to call the ſum *four* balls. After two or three leſſons of this kind with different bodies, his own reflection ſuggeſts to him, that the ſum four has no dependance upon the ſhape or conſiſtence of the bodies, but merely upon the *individuality* of each or their numerical difference; and individuality, or numerical difference, is as completely exemplified in two bodies of any kind as in two thouſand.

23 With its conſequences;

All the truths of pure mathematics (ſays Kant) are *a priori*. If he means that they are all *neceſſary*, and that the contrary of any one of them is *inconceivable*, he affirms nothing but what is true, and has been known to all mathematicians theſe two thouſand years. But, if he means that they are *innate* truths, not diſcovered by induction or ideal meaſurement, his meaning is demonſtrably falſe. (See INDUCTION in this *Supplement*.) When he ſays, that it is not *experience* which diſcovers to us that we ſhall always have the ſurface of the pyramid, by multiplying its baſe by the third part of its height, he is right, if by experience he means the actual meaſurement of all poſſible pyramids; but ſurely he cannot mean that the truth of this meaſurement is innate in the mind, for it is in fact not a true but a falſe meaſurement (G). The baſe of a pyramid multiplied by the third part of its height gives, not the ſurface, but the ſolid contents of the pyramid; and he who underſtands the propoſition on which this truth is immediately built, knows perfectly that Euclid proved it by a ſeries of ideal meaſurements of thoſe particulars in which all pyramids neceſſarily agree.

Kant ſeems often to confound ſenſation with experience; and if by experience he means *ſenſation*, when he ſays that *pure knowledge, a priori,* is that which is abſolutely without any mixture of experience, he talks nonſenſe; for the moſt ſpiritual notions which men can form are derived from the operations of the mind on ideas of ſenſation. To the reſt of the paragraph, reſpecting pure knowledge, we have hardly any objection to make. Locke, the great enemy of innate ideas, taught, before Kant was born, that our knowledge depends upon our organization and the faculties of our minds, as much as upon impreſſions made on the ſenſes *ab extra;* that if our organs of ſenſe were different from what they are, the taſte of ſugar might be bitter, and that of wormwood ſweet; and that if we had not memory, and could not modify and arrange our ideas, all progreſs in knowledge would be impoſſible.

24 Groundleſs or falſe aſſertions. When our author talks of *time* and *ſpace* as the two eſſential *forms* of the mind, we are not ſure that we underſtand him. We have ſhewn elſewhere, that a conſcious intelligence may be conceived which has no ideas either of ſpace or of time (ſee METAPHYSICS, *Encycl.* n° 182, &c. and 209, &c.); and he who can affirm, that if extenſion were known to us only by *experience*, it would be poſſible to conceive ſenſible objects *without ſpace*, has never attended to the force of what philoſophers call *the aſſociation of ideas in the mind*. But what is here meant by ſenſible objects? Are they objects of touch, taſte, or ſmell? Objects of touch cannot indeed be conceived without ſpace; but what extent of ſpace is ſuggeſted by the taſte of ſugar or the odour of a roſe?

When Kant talks of the *form* ſpace enabling us to attribute to external objects *impenetrability, mobility*, &c. he talks at random; and another man may, with as much propriety, and perhaps more truth, affirm the converſe of his propoſitions, and ſay, that it is the impenetrability and mobility, &c. of external objects that enable us to form the idea called *ſpace*, and the ſucceſſion of ſome objects, compared with the permanence of others, that enables us to form the notion or mode called *time*.

On the two or three next paragraphs it is not worth while to detain the reader with many remarks. They abound with the ſame uncouth and obſcure phraſeology, and the ſame idle diſtinctions between ideas *a priori* and *a poſteriori*. In n° 11. he affirms, that the three following propoſitions (*a body is heavy, wood is combuſtible*, and *the three angles of a triangle are equal to two right angles*) are all neceſſary judgments. 25 Bad logic. In one ſenſe this affirmation is true, and in another it is falſe. We cannot, without ſpeaking unintelligibly, give the name *body* to any ſubſtance which is not heavy; and we are not acquainted with any kind of *wood* which is not combuſtible; but ſurely it is not impoſſible to conceive a ſubſtance extended and diviſible, and yet *not* heavy, to which the name *body* might be given without abſurdity, or to conceive wood as incombuſtible as the mineral called *aſbeſtos*. That the three angles, however, of a plane triangle can be either more or leſs than equal to two right angles, is obviouſly impoſſible, and muſt be perceived to be ſo by every intelligence from the Supreme down to the human. The three propoſitions, therefore, are not of the ſame kind, and ſhould not have been claſſed under the ſame genus of *neceſſary* ſynthetic judgments.

In the critique of pure reaſon, Kant ſeems to teach that all demonſtrative ſcience muſt proceed from general principles to particular truths. Hence his *forms* of the underſtanding, and his *categories*, which, according to one of his pupils[*], "lie in our underſtanding as pure notions *a priori*, or the foundation of all our knowledge. They are *neceſſary forms, radical* notions, of which all our knowledge *muſt* be compounded." But this is directly contrary to the progreſs of the human mind, which, as we have ſhewn in the article INDUCTION, already referred to, proceeds, in the acquiſition of every kind of knowledge, from particular truths to general principles. This *tranſcendental philoſophy* of Kant's, therefore, inverts the order of nature, and is as little calculated to promote the progreſs of ſcience as the ſyllogiſtic ſyſtem of Ariſtotle, which was likewiſe built on *categories* or *general forms*. His *tranſcendental æſthetic*, which, according to Dr Willich, is the knowledge *a priori* of the *rules of ſenſation*, ſeems to be a contradictory expreſſion, as it implies that a man may know the laws of ſenſation, without paying the ſmalleſt attention to the organs of ſenſe.

That we know objects only by the manner in which they affect us, and not as they are in themſelves, is a truth admitted, we believe, by all philoſophers, and certainly by Locke and Reid; but when Kant ſays that we know nothing of the *reality* of the objects which affect our ſenſes, he ſeems to be ſingularly paradoxical. Berkeley himſelf, the moſt ingenious idealiſt perhaps that ever wrote, contends ſtrenuouſly for the exiſtence of a *cauſe* of our ſenſations diſtinct from our own minds; and becauſe he thinks inert matter a cauſe inadequate to this effect, he concludes, that every ſenſation of which we are conſcious is a proof of the immediate agency of the Deity. But Kant, as we ſhall perceive by and bye, makes the exiſtence of God and of matter equally problematical. Indeed he ſays expreſsly, that beyond things ſenſible we can only have *opinions* or *belief*; but things ſenſible, as every one knows, are nothing more than the *qualities* of objects.

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[*] Dr Willich.

(G) This may look like cavilling, as the blunder may be either Kant's or our correſpondent's, though neither of them can be ſuppoſed ignorant of the method of meaſuring the ſurface of a pyramid. We aſſure the reader, however, that we do not mean to cavil. We admit that both Kant and our correſpondent know perfectly well how to meaſure the ſurface of a pyramid; but had that knowledge been *innate* in their minds, we cannot conceive the poſſibility of their falling into the blunder. The blunder, therefore, though the offspring of mere inadvertence, ſeems to be a complete confutation of the doctrine.

26 Tendency of the ſyſtem towards atheiſm. It ſhould ſeem that the greater number of wonders which Kant has found in our primitive knowledge and in the faculties of our mind, the greater number of proofs ought he to have found of the exiſtence and attributes of one Firſt Cauſe: but ſo far is this from being the caſe, that we have ſeen him reſting the evidence of this moſt important of all truths, either upon the *moral ſenſe*, which our paſſions and appetites ſo eaſily alter, or upon the intuitive perception of *abſtract moral rectitude*; a perception which thouſands, as virtuous and as profound as he, have conſidered as impoſſible. Our philoſopher's proof of a God is nothing more than his perſuaſion that happineſs is connected with virtue by a Being upon whom nature depends; and he ſays expreſsly, that this proof carries conviction to the mind in proportion as the motives of a man's actions are conformable to the law of morality. This being the caſe, the reader cannot be much ſurpriſed, when he is informed that ſeveral of Kant's diſciples on the continent have avowed themſelves Atheiſts or Spinoziſts. We have elſewhere (ſee ILLUMINATI, n° 37.) mentioned one of thoſe gentlemen who was lately diſmiſſed from his profeſſorial chair in the univerſity of Jena, for making GOD nothing more than an *abſtract idea*, derived from our relations with the moral world. His ſucceſſor, a Kantiſt likewiſe, when it was told in his preſence, that, during one of the maſſacres in Paris, David the Painter ſat with his pencil in his hand, enjoying the ſufferings of the unfortunate wretches, and trying to paint the expreſſions of their agonies, exclaimed—"What force of character! What ſublimity of ſoul!" That this wretch muſt be an Atheiſt, likewiſe, follows of courſe from Kant's principles; for it is not conceivable that he perceives any connection between happineſs and virtue.

That Kant is an atheiſt himſelf, we have not learned, though his doctrine leads thus naturally to atheiſm, and though in his work called TUGEND LEHRE, page 180, he makes the following ſtrange obſervation upon oaths: "As it would be abſurd to ſwear that God exiſts, it is ſtill a queſtion to be determined, whether an oath would be poſſible and obligatory if one were to make it thus—*I ſwear on the ſuppoſition that God exiſts*. It is extremely probable (ſays he), that all *ſincere* oaths, taken with *reflection*, have been taken in no other ſenſe!"

It is not our intention to plunge deeper into this mire of atheiſm, or to enter into a formal confutation of the deteſtable doctrines which have been dragged from its bottom. Enough has been ſaid elſewhere to convince the *theoretical* reaſon of the ſound minds of our countrymen of the exiſtence of one omnipotent, infinitely wiſe, and perfectly good Being, the author and upholder of all things (See *Encycl.* METAPHYSICS, Part III. Chap. vi. and THEOLOGY, Part I. Sect. 1.). It may not, however, be altogether uſeleſs to point out to the reader how completely Kant confutes himſelf, even in the ſhort abſtract that we have given of his ſyſtem.

27 Kant confutes himſelf. Among his *categories*, or fundamental ideas, which are *neceſſarily* formed in the mind, he expreſsly reckons *cauſe* and *effect*: but in various articles of this work, it has been proved beyond the poſſibility of contradiction, that no *ſenſible* object is the *true metaphyſical cauſe* of any one event in nature; and indeed Kant himſelf is at much pains to ſhew that his *categories* or ideas *a priori* are not ideas of ſenſation. There muſt therefore, upon his own principles, be cauſes which are *not* the objects of *ſenſe* or *experience*; and by tracing theſe cauſes backward, if there be a ſucceſſion of them, we muſt arrive at one ſelf-exiſtent cauſe, by a demonſtration as complete as that by which Euclid proves the equality of the three angles of a plane triangle to two right angles. We have no other evidence for the truth of geometrical axioms than the laws of human thought, which compel us to perceive the impoſſibility of ſuch propoſitions being falſe. According to our philoſopher, we have the very ſame evidence for the reality of cauſes and effects which are not the objects of ſenſe. The conſequence is obvious.

28 His morality is extravagant. Kant's *political* opinions are ſaid to be tolerably moderate, though he betrays, what we muſt think, an abſurd confidence in the *unlimited perfectibility* of the human mind. On his morality our valued correſpondent has beſtowed a much larger ſhare of his approbation than we can allow it of ours. Kant ſeems to contend, that the actions of men ſhould be directed to no end whatever; for he expreſsly condemns, as an end of action, the purſuit either of our own happineſs or of the happineſs of others, whether temporal or eternal; but actions performed for no purpoſe are ſurely indications of the very eſſence of folly. Such actions are indeed impoſſible to beings endowed with reaſon, paſſions, and appetites; for if there be that beauty in abſtract virtue, for which Kant and the Stoics contend, it cannot be but that the virtuous man muſt feel an internal pleaſure when he performs a virtuous action, or reflects upon his paſt conduct. He who makes his temporal intereſt the ſole rule of his conduct, has indeed no pretenſions to the character of a virtuous man; but as the morality of the goſpel has always appeared to us ſufficiently pure and diſintereſted, we think a man may, without deviating into vice, have reſpect unto "the recompence of future reward."

PHO PHO

Phoſphorus. **PHOSPHORUS** (See CHEMISTRY-*Index*, *Supplement*.) has lately been employed as a medicine by Alphonſus Leroi, profeſſor at the Medical School of Paris. Its effects, in a variety of caſes, are thus deſcribed in the *Bulletin de la Société Philomatique*, 1798.

1. Phoſphorus adminiſtered internally in conſumptive diſeaſes appears to give a certain degree of activity to life, and to revive the patients, without raiſing their pulſe in the ſame proportion. The author relates ſeveral inſtances that occurred to him in the courſe of his

practice; one of which is as follows: Being called to attend a woman, at the point of death, who was quite worn out by a conſumptive diſorder, with which ſhe had been afflicted for three years, in compliance with the earneſt deſire of her huſband, who requeſted him to give her ſome medicine, he compoſed one of a portion of ſyrup diluted with water, in which a few ſticks of phoſphorus had been kept. Next day the woman found herſelf much better. She was revived for a few days; and did not die till about a fortnight after.

2. He himſelf, as he acknowledges, was ſo imprudent as to take two or three grains of ſolid phoſphorus combined only with treacle, and experienced the moſt dreadful ſymptoms. At firſt he felt a burning heat in the whole region of the ſtomach. That organ ſeemed to be filled with gas which eſcaped by the mouth. Being dreadfully tormented, he tried to vomit, but in vain; and found relief only by drinking cold water from time to time. His uneaſy ſenſations were at length allayed; but next morning he ſeemed to be endowed with an aſtoniſhing muſcular force, and to be urged with an almoſt irreſiſtible impulſe to try its energy. The effect of this medicine at length ceaſed, adds the author, *à la ſuite d'un priapiſme violent*.

3. In many caſes the author employed, and ſtill employs, phoſphorus internally, with great benefit, to reſtore and revive young perſons exhauſted by exceſſes. He divides the phoſphorus into very ſmall particles, by ſhaking it in a glaſs filled with boiling water. He continues to ſhake the bottle, plunging it into cold water, and thus obtains a kind of precipitate of phoſphorus, exceedingly fine, which he bruiſes ſlowly with a little oil and ſugar, or afterwards employs as liquid electuary, by diluting the whole in the yolk of an egg. By means of this medicine he has effected aſtoniſhing cures, and reſtored the ſtrength of his patients in a very ſhort time.

4. In malignant fevers the uſe of phoſphorus internally, to check the progreſs of gangrene, has ſucceeded beyond expectation. The author relates ſeveral inſtances.

5. Pelletier told him, that having left, through negligence, ſome phoſphorus in a copper baſon, that metal was oxydated, and remained ſuſpended in the water. Having thoughtleſsly thrown out the water in a ſmall court in which ducks were kept, theſe animals drank of it, and all died. *Mais le male* (ſays the author) *couvrit toutes ſes femelles juſque au dernier inſtant de ſa vie*. An obſervation which accords with the effect experienced by the author.

6. The author relates a fact which proves the aſtoniſhing diviſibility of phoſphorus. Having adminiſtered to a patient ſome pills, in the compoſition of which there was not more than a quarter of a grain of phoſphorus, and having had occaſion afterwards to open the body, he found all the internal parts luminous; and even the hands of the perſon who had performed the operation, though waſhed and well dried, retained a phoſphoric ſplendor for a long time after.

7. The phoſphoric acid, employed as lemonade, has been ſerviceable to the author in the cure of a great number of diſeaſes.

8. Leroi aſſures us that he oxydated iron with phoſphorus, and obtained, by the common means, a white oxyd, almoſt irreducible, which he thinks may be employed with advantage in the arts, and particularly in painting with oil, and in enamel, inſtead of the white oxyd of lead. This white oxyd of iron occaſioned violent retchings to the author, who ventured to place a very ſmall particle of it on his tongue. He does not heſitate, therefore, to conſider this oxyd as a terrible poiſon. He was not able to reduce it but by fixed alkali and the glaſs of phoſphorus.

9. The author aſſerts that, by means of phoſphorus, he decompoſed and ſeparated from their baſes the ſulphuric, muriatic, and nitric acids; that by help of the phoſphoric acid he tranſmuted earths; and that with calcareous earth he can make, at pleaſure, conſiderable quantities of magneſia. He declares, that to his labours on phoſphorus he is indebted for proceſſes by which he effects the diſſipation (*opère la frite*) of rubies, the fuſion of emeralds, and the vitrification of mercury.

We agree with the editor of the reſpectable Miſcellany *, from which we have immediately taken this article, that Britiſh practitioners will do well to uſe their wonted caution in the application of ſo powerful a remedy. Indeed we conſider it as ſo very *hazardous* a remedy, that we had reſolved to make no mention of it, till we found it tranſcribed into various journals, both foreign and domeſtic, and thence began to ſuſpect that we might be accuſed of culpable negligence, were we to paſs unnoticed what had attracted the attention of ſo many of our fellow-labourers in the field of ſcience.

PHOSPHORUS, in aſtronomy, is the morning ſtar, or the planet Venus, when ſhe riſes before the ſun. The Latins call it *Lucifer*, the French *Etoile de berger*, and the Greeks *Phoſphorus*.

PHOTOMETER, an apparatus for meaſuring the intenſity of light, and likewiſe the tranſparency of the medium through which it paſſes. Inſtruments for this purpoſe have been invented by Count Rumford, M. de Sauſſure, that eminent mathematician and philoſopher Mr John Leſlie, and others. We ſhall content ourſelves with deſcribing in this place the photometer of Count Rumford, and the inſtrument to which Sauſſure gives the name of *diaphanometer*. Mr Leſlie's is indeed the ſimpleſt inſtrument of the kind of which we have anywhere met with a deſcription; but it meaſures only the momentary intenſities of light; and he who wiſhes to be informed of its conſtruction, will find that information in the third volume of Nicholſon's Philoſophical Journal.

Count Rumford, when making the experiments which we have noticed in the article LAMP (*Suppl.*), was led, ſtep by ſtep, to the conſtruction of a very accurate *photometer*, in which the ſhadows, inſtead of being thrown upon a paper ſpread out upon the wainſcot, or ſide of the room (See page 64 of this volume), are projected upon the inſide of the back part of a wooden box $7\frac{1}{4}$ inches wide, $10\frac{1}{2}$ inches long, and $3\frac{1}{4}$ inches deep, in the clear. The light is admitted into it through two horizontal tubes in the front, placed ſo as to form an angle of 60°; their axes meeting at the centre of the field of the inſtrument. In the middle of the front of the box, between theſe two tubes, is an opening thro' which is viewed the field of the photometer (See fig. 1.). This field is formed of a piece of white paper, which is not faſtened immediately upon the inſide of the back of the box, but is paſted upon a ſmall pane of very fine ground glaſs; and this glaſs, thus covered, is

Plate XLI.

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* Philoſophical Magazine, vol ii.

is let down into a groove, made to receive it, in the back of the box. The whole inſide of the box, except the field of the inſtrument, is painted of a deep black dead colour. To the under part of the box is fitted a ball and ſocket, by which it is attached to a ſtand which ſupports it; and the top or lid of it is fitted with hinges, in order that the box may be laid quite open, as often as it is neceſſary to alter any part of the machinery it contains.

The Count had found it very inconvenient to compare two ſhadows projected by the ſame cylinder, as theſe were either neceſſarily too far from each other to be compared with certainty, or, when they were nearer, were in part hid from the eye by the cylinder. To remedy this inconvenience, he now makes uſe of two cylinders, which are placed perpendicularly in the bottom of the box juſt deſcribed, in a line parallel to the back part of it, diſtant from this back $2\frac{2}{10}$ inches, and from each other 3 inches, meaſuring from the centres of the cylinders; when the two lights made uſe of in the experiment are properly placed, theſe two cylinders project four ſhadows upon the white paper upon the inſide of the back part of the box, or the *field* of the inſtrument; two of which ſhadows are in contact, preciſely in the middle of that field, and it is theſe two alone that are to be attended to. To prevent the attention being diſtracted by the preſence of unneceſſary objects, the two outſide ſhadows are made to diſappear; which is done by rendering the field of the inſtrument ſo narrow, that they fall without it, upon a blackened ſurface, upon which they are not viſible. If the cylinders be each $\frac{4}{10}$ of an inch in diameter, and $2\frac{2}{10}$ inches in height, it will be quite ſufficient that the field be $2\frac{7}{10}$ inches wide; and as an unneceſſary height of the field is not only uſeleſs, but diſadvantageous, as a large ſurface of white paper not covered by the ſhadows produces too ſtrong a glare of light, the field ought not to be more than $\frac{3}{10}$ of an inch higher than the tops of the cylinders. That its dimenſions, however, may be occaſionally augmented, the covered glaſs ſhould be made $5\frac{1}{4}$ inches long, and as wide as the box is deep, viz. $3\frac{1}{2}$ inches; ſince the field of the inſtrument can be reduced to its proper ſize by a ſcreen of black paſteboard, interpoſed before the anterior ſurface of this covered glaſs, and reſting immediately upon it. A hole in this paſteboard, in the form of an oblong ſquare, $1\frac{7}{10}$ inch wide, and two inches high, determines the dimenſions, and forms the boundaries of the field. This ſcreen ſhould be large enough to cover the whole inſide of the back of the box, and it may be fixed in its place by means of grooves in the ſides of the box, into which it may be made to enter. The poſition of the opening above-mentioned is determined by the height of the cylinders; the top of it being $\frac{3}{10}$ of an inch higher than the tops of the cylinders; and as the height of it is only two inches, while the height of the cylinders is $2\frac{2}{10}$ inches, it is evident that the ſhadows of the lower parts of the cylinders do not enter the field. No inconvenience ariſes from that circumſtance; on the contrary, ſeveral advantages are derived from that arrangement.

That the lights may be placed with facility and preciſion, a fine black line is drawn through the middle of the field, from the top to the bottom of it, and another (horizontal) line at right angles to it, at the height of the top of the cylinders. When the tops of the ſhadows touch this laſt mentioned line, the lights are at a proper height; and farther, when the two ſhadows are in contact with each other in the middle of the field, the lights are then in their proper directions.

We have ſaid that the cylinders, by which the ſhadows are projected, are placed perpendicularly in the bottom of the box; but as the diameters of the ſhadows of theſe cylinders vary in ſome degree, in proportion as the lights are broader or narrower, and as they are brought nearer to or removed farther from the photometer, in order to be able in all caſes to bring theſe ſhadows to be of the ſame diameter, which is very advantageous, in order to judge with greater facility and certainty when they are of the ſame denſity, the Count renders the cylinders moveable about their axes, and adds to each a vertical wing $\frac{11}{10}$ of an inch wide, $\frac{1}{10}$ of an inch thick, and of equal height with the cylinder itſelf, and firmly fixed to it from the top to the bottom. This wing commonly lies in the middle of the ſhadow of the cylinder, and as long as it remains in that ſituation it has no effect whatever; but when it is neceſſary that the diameter of one of the ſhadows be increaſed, the correſponding cylinder is moved about its axis, till the wing juſt deſcribed, emerging out of the ſhadow, and intercepting a portion of light, brings the ſhadow projected upon the field of the inſtrument to be of the width or diameter required. In this operation it is always neceſſary to turn the cylinder outwards, or in ſuch a manner that the augmentation of the width of the ſhadow may take place on that ſide of it which is oppoſite to the ſhadow correſponding to the other light. The neceſſity for that precaution will appear evident to any one who has a juſt idea of the inſtrument in queſtion, and of the manner of making uſe of it. They are turned likewiſe without opening the box, by taking hold of the ends of their axes, which project below its bottom.

As it is abſolutely neceſſary that the cylinders ſhould conſtantly remain preciſely perpendicular to the bottom of the box, or parallel to each other, it will be beſt to conſtruct them of braſs; and, inſtead of fixing them immediately to the bottom of the box (which, being of wood, may warp), to fix them to a ſtrong thick piece of well-hammered plate braſs; which plate of braſs may be afterwards faſtened to the bottom of the box by means of one ſtrong ſcrew. In this manner two of the Count's beſt inſtruments are conſtructed; and, in order to ſecure the cylinders ſtill more firmly in their vertical poſitions, they are furniſhed with broad flat rings, or projections, where they reſt upon the braſs plate; which rings are $\frac{1}{10}$ of an inch thick, and equal in diameter to the projection of the wing of the cylinder, to the bottom of which they afford a firm ſupport. Theſe cylinders are likewiſe forcibly puſhed, or rather pulled, againſt the braſs plate upon which they reſt, by means of compreſſed ſpiral ſprings placed between the under ſide of that plate and the lower ends of the cylinders. Of whatever material the cylinders be conſtructed, and whatever be their forms or dimenſions, it is abſolutely neceſſary that they, as well as every other part of the photometer, except the field, ſhould be well painted of a deep black dead colour.

In order to move the lights to and from the photometer with greater eaſe and preciſion, the obſerver ſhould provide two long and narrow, but very ſtrong and ſteady, tables; in the middle of each of which there is a ſtraight groove, in which a ſliding carriage, upon which the light is placed, is drawn along by means of a cord which is faſtened to it before and behind, and which, paſſing over pulleys at each end of the table, goes round a cylinder; which cylinder is furniſhed with a winch, and is ſo placed, near the end of the table adjoining the photometer, that the obſerver can turn it about, without taking his eye from the field of the inſtrument.

Many advantages are derived from this arrangement: Firſt, the obſerver can move the lights as he finds neceſſary, without the help of an aſſiſtant, and even without removing his eye from the ſhadows; ſecondly, each light is always preciſely in the line of direction in which it ought to be, in order that the ſhadows may be in contact in the middle of the vertical plane of the photometer; and, thirdly, the ſliding motion of the lights being perfectly ſoft and gentle, that motion produces little or no effect upon the lights themſelves, either to increaſe or diminiſh their brilliancy.

Theſe tables muſt be placed at an angle of 60 degrees from each other, and in ſuch a ſituation, with reſpect to the photometer, that lines drawn through their middles, in the direction of their lengths, meet in a point exactly under the middle of the vertical plane or field of the photometer, and from that point the diſtances of the lights are meaſured; the ſides of the tables being divided into Engliſh inches, and a vernier, ſhewing tenths of inches, being fixed to each of the ſliding carriages upon which the lights are placed, and which are ſo contrived that they may be raiſed or lowered at pleaſure; ſo that the lights may be always in a horizontal line with the tops of the cylinders of the photometer.

In order that the two long and narrow tables or platforms, juſt deſcribed, may remain immoveable in their proper poſitions, they are both firmly fixed to the ſtand which ſupports the photometer; and, in order that the motion of the carriages which carry the lights may be as ſoft and gentle as poſſible, they are made to ſlide upon parallel braſs wires, 9 inches aſunder, about $\frac{1}{10}$ of an inch in diameter, and well poliſhed, which are ſtretched out upon the tables from one end to the other.

The ſtructure of the apparatus will be clearly underſtood by a bare inſpection of Plate XLI. where fig. 1. is a plan of the inſide of the box, and the adjoining parts of the photometer. Fig. 2. Plan of the two tables belonging to the photometer. Fig. 3. The box of the photometer on its ſtand. Fig. 4. Elevation of the photometer, with one of the tables and carriages.

Having ſufficiently explained all the eſſential parts of this photometer, it remains for us to give ſome account of the precautions neceſſary to be obſerved in uſing it. And, firſt, with reſpect to the diſtance at which lights, whoſe intenſities are to be compared, ſhould be placed from the field of the inſtrument, the ingenious and accurate inventor found, that when the weakeſt of the lights in queſtion is about as ſtrong as a common wax-candle, that light may moſt advantageouſly be placed from 30 to 36 inches from the centre of the field; and when it is weaker or ſtronger, proportionally nearer or farther off. When the lights are too near, the ſhadows will not be well defined; and when they are too far off, they will be too weak.

It will greatly facilitate the calculations neceſſary in drawing concluſions from experiments of this kind, if ſome ſteady light, of a proper degree of ſtrength for that purpoſe, be aſſumed as a ſtandard by which all others may be compared. Our author found a good Argand's lamp much preferable for this purpoſe to any other lamp or candle whatever. As it appears, he ſays, from a number of experiments, that the quantity of light emitted by a lamp, which burns in the ſame manner with a clear flame, and *without ſmoke*, is in all caſes as the quantity of oil conſumed, there is much reaſon to ſuppoſe, that, if the Argand's lamp be ſo adjuſted as always to conſume a given quantity of oil in a given time, it may then be depended on as a juſt ſtandard of light.

In order to abridge the calculations neceſſary in theſe inquiries, it will always be advantageous to place the ſtandard-lamp at the diſtance of 100 inches from the photometer, and to aſſume the intenſity of its light at its ſource equal to unity; in this caſe (calling this ſtandard light A, the intenſity of the light at its ſource $= x = 1$, and the diſtance of the lamp from the field of the photometer $= m = 100$), the intenſity of the illumination at the field of the photometer $(= \frac{x}{m^2})$ (See Lamp, p. 67. of this volume) will be expreſſed by the fraction $\frac{1}{100^2} = \frac{1}{10000}$; and the relative intenſity of any other light which is compared with it, may be found by the following proportion: Calling this light B, putting $y =$ its intenſity at its ſource, and $n =$ its diſtance from the field of the photometer, expreſſed in Engliſh inches, as it is $\frac{y}{n^2} = \frac{x}{m^2}$, as was ſhewn in the article Lamp referred to; or, inſtead of $\frac{x}{m^2}$, writing its value $= \frac{1}{10000}$, it will be $\frac{y}{n^2} = \frac{1}{10000}$; and conſequently y is to 1 as n^2 is to 10000; or the intenſity of the light B at its ſource, is to the intenſity of the ſtandard light A at its ſource, as the ſquare of the diſtance of the light B from the middle of the field of the inſtrument, expreſſed in inches, is to 10000; and hence it is $y = \frac{n^2}{10000}$.

Or, if the light of the ſun, or that of the moon, be compared with the light of a given lamp or candle C, the reſult of ſuch compariſon may beſt be expreſſed in words, by ſaying, that the light of the celeſtial luminary in queſtion, *at the ſurface of the earth*, or, which is the ſame thing, at the field of the photometer, is equal to the light of the given lamp or candle, *at the diſtance found by the experiment*; or, putting $a =$ the intenſity of the light of this lamp C at its ſource, and $p =$ its diſtance, in inches, from the field, when the ſhadows correſponding to this light, and that correſponding to the celeſtial luminary in queſtion, are found to be of equal denſities, and putting $z =$ the intenſity of the rays of the luminary at the ſurface of the earth, the reſult of the experiment may be expreſſed thus, $z = \frac{a}{p^2}$; or the real value of a being determined by a particular experiment, made expreſsly for that purpoſe with the ſtandard lamp, that value may be written inſtead of it. When the ſtandard-lamp itſelf is made uſe of, inſtead of the lamp C, then the value of A will be 1.

The Count's firſt attempts with his photometer were to determine how far it might be poſſible to aſcertain, by direct experiments, the certainty of the aſſumed law of the diminution of the intenſity of the light emitted by luminous bodies; namely, that the intenſity of the light is everywhere as the ſquares of the diſtances from the luminous body inverſely. As it is obvious that this law can hold good only when the light is propagated through perfectly tranſparent ſpaces, ſo that its intenſity is weakened merely by the divergency of its rays, he inſtituted a ſet of experiments to aſcertain the tranſparency of the air and other mediums.

With this view, two equal wax candles, well trimmed, and which were found, by a previous experiment, to burn with exactly the ſame degree of brightneſs, were placed *together*, on one ſide, before the photometer, and their united light was counterbalanced by the light of an Argand's lamp, well trimmed, and burning very equally, placed on the other ſide over againſt them. The lamp was placed at the diſtance of 100 inches from the field of the photometer, and it was found that the two burning candles (which were placed as near together as poſſible, without their flames affecting each other by the currents of air they produced) were juſt able to counterbalance the light of the lamp at the field of the photometer, when they were placed at the diſtance of 60,8 inches from that field. One of the candles being now taken away and extinguiſhed, the other was brought nearer to the field of the inſtrument, till its light was found to be juſt able, ſingly, to counterbalance the light of the lamp; and this was found to happen when it had arrived at the diſtance of 43,4 inches. In this experiment, as the candles burnt with equal brightneſs, it is evident that the intenſities of their united and ſingle lights were as 2 to 1, and in that proportion ought, according to the aſſumed theory, the ſquares of the diſtances, 60,8 and 43,4, to be; and, in fact, $\overline{60,8}^2 = 3696,64$ is to $\overline{43,4}^2 = 1883,56$ as 2 is to 1 very nearly.

Again, in another experiment, the diſtances were,
With two candles = 54 inches. Square = 2916
With one candle = 38,6 - - = 1489,96

Upon another trial,
With two candles = 54,6 inches. Square = 2981,16
With one candle = 39,7 - - = 1576,09

And, in the fourth experiment,
With two candles = 58,4 inches. Square = 3410,56
With one candle = 42,2 - - - = 1780,84

And, taking the mean of the reſults of theſe four experiments,

	Squares of the Diſtances With two Candles.		With one Candle.
In the Experiment N° 1.	3696,64	—	1883,56
N° 2.	2916	—	1489,96
N° 3.	2981,16	—	1576,09
N° 4.	3410,56	—	1780,84
	4) 13004,36		4) 6730,45
Means	3251,09	and	1682,61

which again are very nearly as 2 to 1.

With regard to theſe experiments, it may be obſerved, that were the reſiſtance of the air to light, or the diminution of the light from the imperfect tranſparency of air, ſenſible within the limits of the inconſiderable diſtances at which the candles were placed from the photometer, in that caſe the diſtance of the two equal lights united ought to be, to the diſtance of one of them ſingle, in a ratio leſs than that of the ſquare root of 2 to the ſquare root of 1. For if the intenſity of a light emitted by a luminous body, *in a ſpace void of all reſiſtance*, be diminiſhed in the proportion of the ſquares of the diſtances, it muſt of neceſſity be diminiſhed in a ſtill higher ratio when the light paſſes thro' a reſiſting medium, or one which is not perfectly tranſparent; and from the difference of thoſe ratios, namely, that of the ſquares of the diſtances, and that other higher ratio found by the experiment, the reſiſtance of the medium might be aſcertained. This he took much pains to do with reſpect to air, but did not ſucceed; the tranſparency of air being ſo great, that the diminution which light ſuffers in paſſing through a few inches, or even through ſeveral feet of it, is not ſenſible.

Having found, upon repeated trials, that the light of a lamp, properly trimmed, is incomparably more equal than that of a candle, whoſe wick, continually growing longer, renders its light extremely fluctuating, he ſubſtituted lamps to candles in theſe experiments, and made ſuch other variations in the manner of conducting them as he thought bid fair to lead to a diſcovery of the reſiſtance of the air to light, were it poſſible to render that reſiſtance ſenſible within the confined limits of his machinery. But the reſults of them, ſo far from affording means for aſcertaining the reſiſtance of the air to light, do not even indicate any reſiſtance at all; on the contrary, it might almoſt be inferred, from ſome of them, that the intenſity of the light emitted by a luminous body in air is diminiſhed in a ratio *leſs* than that of the ſquares of the diſtances; but as ſuch a concluſion would involve an evident abſurdity, namely, that light moving in air, its abſolute quantity, inſtead of being diminiſhed, actually goes on to *increaſe*, that concluſion can by no means be admitted.

Why not? Theories muſt give place to facts; and if this fact can be fairly aſcertained, inſtead of rejecting the concluſion, we ought certainly to rectify our notions of light, the nature of which we believe no man fully comprehends. Who can take it upon him to ſay, that the ſubſtance of light is not latent in the atmoſphere, as heat or caloric is now acknowledged to be latent, and that the agency of the former is not called forth by the paſſage of a ray through a portion of air, as the agency of the latter is known to be excited by the combination of oxygen with any combuſtible ſubſtance? See CHEMISTRY, n° 293. *Suppl.*

The ingenious author's experiments all conſpired to ſhew that the reſiſtance of the air to light is too inconſiderable to be perceptible, and that the aſſumed law of the diminution of the intenſity of light may be depended upon with ſafety. He admits, however, that means may be found for rendering the air's reſiſtance to light apparent; and he ſeems to have thought of the very means which occurred for this purpoſe to M. de Sauſſure.

That eminent philoſopher, wiſhing to aſcertain the tranſparency of the atmoſphere, by meaſuring the diſtances at which determined objects ceaſe to be viſible, perceived at once that his end would be attained, if he ſhould find objects of which the diſappearance might be accurately determined. Accordingly, after many trials, he found that the moment of diſappearance can be obſerved with much greater accuracy when a black object is placed on a white ground, than when a white object is placed on a black ground; that the accuracy was ſtill greater when the obſervation was made in the ſun than in the ſhade; and that even a ſtill greater degree of accuracy was obtained, when the white ſpace ſurrounding a black circle, was itſelf ſurrounded by a circle or ground of a dark colour. This laſt circumſtance was particularly remarkable, and an obſervation quite new.

If a circle totally black, of about two lines in diameter, be faſtened on the middle of a large ſheet of paper or paſteboard, and if this paper or paſteboard be placed in ſuch a manner as to be expoſed fully to the light of the ſun, if you then approach it at the diſtance of three or four feet, and afterwards gradually recede from it, keeping your eye conſtantly directed towards the black circle, it will appear always to decreaſe in ſize the farther you retire from it, and at the diſtance of 33 or 34 feet will have the appearance of a point. If you continue ſtill to recede, you will ſee it again enlarge itſelf; and it will ſeem to form a kind of cloud, the darkneſs of which decreaſes more and more according as the circumference becomes enlarged. The cloud will appear ſtill to increaſe in ſize the farther you remove from it; but at length it will totally diſappear. The moment of the diſappearance, however, cannot be accurately aſcertained; and the more experiments were repeated the more were the reſults different.

M. de Sauſſure, having reflected for a long time on the means of remedying this inconveniency, ſaw clearly, that, as long as this cloud took place, no accuracy could be obtained; and he diſcovered that it appeared in conſequence of the contraſt formed by the white parts which were at the greateſt diſtance from the black circle. He thence concluded, that if the ground was left white near this circle, and the parts of the paſteboard at the greateſt diſtance from it were covered with a dark colour, the cloud would no longer be viſible, or at leaſt almoſt totally diſappear.

This conjecture was confirmed by experiment. M. de Sauſſure left a white ſpace around the black circle equal in breadth to its diameter, by placing a circle of black paper a line in diameter on the middle of a white circle three lines in diameter, ſo that the black circle was only ſurrounded by a white ring a line in breadth. The whole was paſted upon a green ground. A green colour was choſen, becauſe it was dark enough to make the cloud diſappear, and the eaſieſt to be procured

The black circle, ſurrounded in this manner with white on a green ground, diſappeared at a much leſs diſtance than when it was on a white ground of a large ſize.

If a perfectly black circle, a line in diameter, be paſted on the middle of a white ground expoſed to the open light, it may be obſerved at the diſtance of from 44 to 45 feet; but if this circle be ſurrounded by a white ring a line in breadth, while the reſt of the ground is green, all ſight of it is loſt at the diſtance of only 15½ feet.

According to theſe principles M. de Sauſſure delineated ſeveral black circles, the diameters of which increaſed in a geometrical progreſſion, the exponent of which was $\frac{3}{2}$. His ſmalleſt circle was $\frac{1}{5}$ or 0·2 of a line in diameter; the ſecond 0·3; the third, 0·45; and ſo on to the ſixteenth, which was 87·527, or about 7 inches 3½ lines. Each of theſe circles was ſurrounded by a white ring, the breadth of which was equal to the diameter of the circle, and the whole was paſted on a green ground.

M. de Sauſſure, for his experiments, ſelected a ſtraight road or plain of about 1200 or 1500 feet in circumference, which towards the north was bounded by trees or an aſcent. Thoſe who repeat them, however, muſt pay attention to the following remarks: When a perſon retires backwards, keeping his eye conſtantly fixed on the paſteboard, the eye becomes fatigued, and ſoon ceaſes to perceive the circle; as ſoon therefore as it ceaſes to be diſtinguiſhable, you muſt ſuffer your eyes to reſt; not, however, by ſhutting them, for they would when again opened be dazzled by the light, but by turning them gradually to ſome leſs illuminated object in the horizon. When you have done this for about half a minute, and again directed your eyes to the paſteboard, the circle will be again viſible, and you muſt continue to recede till it diſappear once more. You muſt then let your eyes reſt a ſecond time in order to look at the circle again, and continue in this manner till the circle becomes actually inviſible.

If you wiſh to find an accurate expreſſion for the want of tranſparency, you muſt employ a number of circles, the diameters of which increaſe according to a certain progreſſion; and a compariſon of the diſtances at which they diſappear will give the law according to which the tranſparency of the atmoſphere decreaſes at different diſtances. If you wiſh to compare the tranſparency of the atmoſphere on two days, or in two different places, two circles will be ſufficient for the experiment.

According to theſe principles, M. de Sauſſure cauſed to be prepared a piece of white linen cloth eight feet ſquare. In the middle of this ſquare he ſewed a perfect circle, two feet in diameter, of beautiful black wool; around this circle he left a white ring two feet in breadth, and the reſt of the ſquare was covered with pale green. In the like manner, and of the ſame materials, he prepared another ſquare; which was, however, equal to only $\frac{1}{12}$ of the ſize of the former, ſo that each ſide of it was 8 inches; the black circle in the middle was two inches in diameter, and the white ſpace around the circle was 2 inches alſo.

If two ſquares of this kind be ſuſpended vertically and parallel to each other, ſo that they may be both illuminated in an equal degree by the ſun; and if the atmoſphere, at the moment when the experiment is made, be perfectly tranſparent, the circle of the large ſquare, which is twelve times the ſize of the other, muſt be ſeen at twelve times the diſtance. In M. de Sauſſure's experiments the ſmall circle diſappeared at the diſtance of 314 feet, and the large one at the diſtance of 3588 feet, whereas it ſhould have diſappeared at the diſtance of 3768. The atmoſphere, therefore, was not perfectly tranſparent. This aroſe from the thin vapours which at that time were floating in it. M. de Sauſſure, as we have obſerved, calls his inſtrument a *diaphanometer*; but as it anſwers one of the purpoſes of a photometer, we truſt our readers will not conſider this account of it as a digreſſion.

To return to Count Rumford. From a number of experiments made with his *photometer*, he found that, by paſſing through a pane of fine, clear, well poliſhed glaſs, ſuch as is commonly made uſe of in the conſtruction of looking-glaſſes, light loſes ·1973 of its whole

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quantity, *i. e.* of the quantity which impinged on the glaſs; that when light is made to paſs through two panes of ſuch glaſs ſtanding parallel, but not touching each other, the loſs is ,3184 of the whole; and that in paſſing through a very thin, clear, colourleſs pane of window-glaſs, the loſs is only ,1263. Hence he infers, that this apparatus might be very uſefully employed by the optician, to determine the degree of tranſparency of glaſs, and direct his choice in the proviſion of that important article of his trade. The loſs of light when reflected from the very beſt plain glaſs mirror, the author aſcertained, by five experiments, to be $\frac{1}{3}$d of the whole which fell upon the mirror.

PIANO FORTE, otherwiſe called FORTE PIANO, a well known muſical inſtrument, of which we need make no apology for conſidering the peculiarities with ſome attention. If we look on muſic from no higher point of view than as the *laborum dulce lenimen*, the innocent, the ſoothing, the chearing ſweetener of toil, we muſt acknowledge that it is far from being the meaneſt of thoſe enjoyments with which the Bountiful Father of Men has embelliſhed this ſcene of our exiſtence. But there is a *ſcience* in muſic, independent of that artificial half mathematical doctrine which we have contrived to unite with it, and which really enables us to improve pure muſical pleaſure. Hence in the Engliſh univerſities degrees are conferred in muſic.

The voice is the original muſical inſtrument, and all others are but imitations. The voice of man obeys the impulſe of the heart with wonderful promptitude, and ſtill more wonderful accuracy. A very coarſe ear is hurt by an error in its tone, amounting to what is called a *comma*. A very limited voice can execute melodies extending to 12 notes, or an octave and a fifth. The motion of the glottis between theſe extremes does not amount to $\frac{1}{11}$th of an inch. This muſt therefore be divided, by the moſt ordinary ſinger, into more than a thouſand parts; and this muſt be done in an inſtant, and repeated with rapidity, without ever miſtaking one of theſe diviſions; and this is done everywhere, and without any ſeeming effort or thought. The mechaniſm of the human organ for effecting this with eaſe and preciſion is very remarkable, and ſeems to prove that the Author of our Being meant to give us this pleaſure.

When, in the cultivation of this fruit of our own ſoil, the moderns diſcovered the beauties of harmony or conſonance, and inſtruments of fixed ſounds were employed, by means of which theſe beauties could be exhibited in their utmoſt richneſs and variety; and particularly when the organ, that "magic world of ſound," was invented, the immenſe advantages of the ingenious ſpeculations of the ancient Greeks about the diviſion of the monochord were now perceived, and muſic became a deep intellectual ſtudy. It fell into the hands of men of letters, and, for a long while, counterpoint occupied all their attention. Inſtruments of fixed ſounds were now made, not only with pipes, but with ſtrings, bells, rings, and every thing that could make a noiſe in tune.

But all theſe inſtruments were far inferior to the voice, the ſpontaneous gift of Nature, in promptitude, and in the power of obeying every call of ſentiment, every degree, as well as every kind of emotion, with which the heart was agitated. The pleaſures of harmony, though great, were monotonous, and could not expreſs the momentary variations of ſentiment, which are as fleeting as the light and ſhade of a proſpect while the dappled clouds ſail acroſs the ſky. The violin, and a ſmall number of the ſimple wind inſtruments, were found to be the only ones which could fully expreſs thoſe momentary gradations of ſentiment that give muſic its pathos, and enable it to thrill the very ſoul.

Attempts were made to remove this defect of the harmonic inſtruments, and the SWELL was added to the organ. The effect was great, and encouraged the artiſts to attempt ſimilar improvements on other inſtruments of the ſame kind. This was firſt done in the ſame way as in the organ. The harpſichord was ſhut up, like the ſwell organ, and was opened by means of pedals when the performer wiſhed to enforce the ſound. But the effect was far inferior to that of the ſwell organ; for this was (at leaſt in all great organs) a real addition of another properly ſelected ſound. But the effect of the pedal on the harpſichord could not be miſtaken; it was juſt like opening the door of a room where muſic was performing. Other methods were tried with better effect. Uniſons were added to each note, which were brought on either by means of pedals or by another ſet of keys.

This method ſucceeded perfectly well, and the power of the harpſichord was greatly improved. But ſtill it was imperfect, becauſe it was only the more conſiderable changes of force which could be exhibited, and this only in one or two degrees. Other artiſts, therefore, attempted to conſtruct the inſtrument, ſo that the jacks (the moveable upright pieces which carry the quills) can be made to approach nearer to the wires, ſo that the quills ſhall give them a ſtronger twang. The mechaniſm was ſuch, that a very conſiderable motion of the pedal produced but a moſt minute motion of the quill; ſo that the performer was not reſtricted to the utmoſt preciſion in the degree of preſſure. Some of thoſe inſtruments, when freſh from the hand of the artiſt, gave full ſatisfaction. But, though made in the moſt accurate manner, at an enormous expence, they very ſoon become unfit for the purpoſe. The hundredth part of an inch, more or leſs, in the place of the quill, will make a great odds in the force of the ſound. Nor does the ſame change of diſtance produce an equal alteration of ſound on different quills. Other inſtrument makers have therefore tried baked or prepared leather (buffalo hide) in place of quills; and it is found much more uniform in the tone which it produces, and alſo remains longer in the ſame ſtate; but the tone is not ſo powerful, nor in general ſo much reliſhed.

But all theſe contrivances, both in the organ and harpſichord, were ſtill very deficient. Whatever change they could produce in the ſtrength of the ſound, was produced through the whole inſtrument, or at leaſt through two or three octaves. But the captivating expreſſion of muſic frequently reſults from the momentary ſwelling or ſoftening of a ſingle phraſe, or a ſingle note, in one of the parts. Hence ariſe the unrivalled powers of the harp, and the acknowledged ſuperiority of the theorbo, the lute, and even the guitar, over all keyed inſtruments, notwithſtanding their great limitations in harmony and in practicable melodies. Theſe inſtruments ſpeak, while the harpſichord only plays.

Many attempts have been made to enable the performer to produce, by the intervention of the key, all the gradations of ſtrength, and even the varieties of

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ſound, which the finger can bring forth by the different manner of pinching, bruſhing, or, as it were, careſſing the ſtring; but we have no diſtinct account of any attempt that has ſucceeded. Such a thing would quickly ſpread over Europe. The compiler of the article LUTHIER, in the *Encyclopedie Methodique*, ſays a great deal about a harpſichord fitted with prepared buffalo leather inſtead of crow quills; and aſſerts expreſsly, that, by the mere preſſure on the key, without the aſſiſtance of pedals or ſtops of any kind, the leather is made to act with greater or leſs force on the ſtring. But he gives no account by which we can comprehend how this is brought about; and indeed he writes in terms which ſhew plainly that he has not ſeen the inſtrument, and is merely puffing ſomething that he does not underſtand.

The attempt has been made with more ſucceſs on keyed inſtruments, when the ſtrings are not pinched, but are rubbed by a wheel or band, in the manner of the vielle (hurdygurdy), or ſtruck with a plectrum, like the dulcimer. The CELESTINA (deſcribed by Merſennus by the name of ARCHIVIOLA) is of this kind. A fine band of horſe hair or ſilk, filled with roſin, is extended under the ſtrings, and drawn ſmoothly along by a wheel. By a particular mechaniſm of the keys, this band is made to preſs or rub on any ſtring tranſverſely, as the ſtrings of a violin are touched by the bow. The preſſure on the key regulates the ſtrength of the tone. This inſtrument is not without conſiderable beauties, and will execute ſoft *cantabile* muſic in eaſy modulation, with great expreſſion and juſtneſs. But the artiſts have not yet been able to give it either clearneſs or brilliancy of tone, nor ſufficient force for concert muſic, nor that promptitude of touch that is indiſpenſably neceſſary for figurative muſic or quick movements.

The ſame improvements have been made on the pulſatile inſtruments; and indeed they are here the moſt obvious and eaſy. When the key is employed merely as the means of cauſing a plectrum to give a blow to the ſtring, the performer will hardly fail to give that degree of force which he feels proper for his intended expreſſion. Accordingly, many inſtruments of this kind have been made in Germany, where the artiſts have long been eminent for mechanical knacks. But all their inſtruments of the dulcimer kind are feeble and ſpiritleſs, and none of them have been brought into general uſe, if we except the CLAVICHORD. This is indeed an inſtrument of feeble, and not the moſt pleaſing ſound; but is well fitted for giving every momentary gradation of ſtrength by the preſſure of the finger. Is is therefore a good inſtrument for forming the muſical taſte by chamber practice, and was much uſed by compoſitors in their ſtudies. It is alſo an ingenious, though ſeemingly an obvious and ſimple contrivance, and is capable of much more force, and even brilliancy of ſound, than has generally been given to it.

The conſtruction is ſhortly this. The inner end of the key is furniſhed with an upright piece, which terminates in an edge of braſs, ſomewhat like the end of a narrow blunt chiſel, whoſe line of direction is athwart the ſtrings. When the key is preſſed down, this edge ſtrikes the ſtring, and forces it out of the ſtraight line in which it is ſtretched between its pins. Thus the ſtring is ſhaken or jogged into vibration, in the ſame manner as we obſerve a tight rope ſet a vibrating by a ſudden jerk given to any part of it. The ſtring, thus agitated, gives a ſound, which will continue for ſome little time if the key be held down. As the tone depends on the length of the vibrating ſtring, as well as on its tenſion, it is of importance that the ſtroke be made on the preciſe point of the ſtring which terminates the proper length. The ſtring does not give the note correſponding to its whole length, but that which is produced by the part between the edge and the pin. And becauſe the parts of the ſtring on each ſide of the edge are equally thrown into vibration, the ſhorter portion of it muſt be wrapped up in a liſt of cloth, to prevent it from diſturbing the ear by its ſonorous vibrations. This, however, greatly diminiſhes the ſweetneſs of the ſound given by the other part.

The clavichord gives a fretful waſpiſh kind of ſound, not at all ſuited to tender expreſſion. If the bridge (for the end of the key is really a bridge during the ſound) were placed at an exact third of the length of the ſtring, and if both parts were free, and if the ſtroke be of a proper ſtrength, the ſtring would ſound its twelfth with great ſweetneſs, and with much more force and brilliancy than it does by the preſent conſtruction, and the clavichord would be a charming inſtrument for a leſſon and for private ſtudy. We ſay this from experience of the power of one conſtructed under the direction of the great mathematician Euler, who was alſo an excellent judge of muſic and muſical compoſition. The tones of the upper part of that inſtrument had a ſort of pipe or vocal ſound, and were ſuperior in clearneſs and ſweetneſs to any ſtringed inſtrument we ever heard. But as this conſtruction required every ſtring to be one half longer than a harpſichord wire of the ſame pitch, and as this would have made the inſtrument of a moſt inconvenient ſize, the baſſes were made ſhorter, by placing the bridge at one-ſixth of the length, and loading the ſhorter portion of the ſtring with wire twiſted round it. But although this was executed by a moſt dexterous artiſt, the tones were far inferior to thoſe of the trebles, and the inſtrument was like the junction of a very fine one and a very bad one, and made but hobbling muſic. This was probably owing to the impoſſibility of connecting the metal wire and its covering with ſufficient cloſeneſs and ſolidity. An upright clavichord, where the length would be no inconvenience, would be indeed a capital inſtrument for muſical ſtudy. It is worthy of remark, that Mr Euler tried other diviſions of the ſtring by the bridge. When it is ſtruck preciſely in the middle, it ſhould ſound its octave; when it is ſtruck at one-fourth, it ſhould give the double octave, &c. But the maker found that theſe diviſions gave very indifferent, and even uncertain tones; ſometimes not ſounding at all, and ſometimes ſounding beautifully. Our readers will find this well explained in a future article of this *Supplement*, (TRUMPET, *Marine*). They may pleaſe to reflect on the very different tone of the violin as it is bowed on different parts of the ſtring, and on the very different tones of the fore and back uniſons, and particularly of the Cornet ſtop of the harpſichord. The harpſichords of Rucker are noted for the grand fulneſs of their tone; thoſe of Haſſe of Dreſden for their mellow ſweetneſs, and thoſe of Kirkmann of London for their unequalled brilliancy. Theſe makers differed greatly in the placing of their quills.

But the Engliſh PIANO FORTE, by its ſuperior force of tone, its adequate ſweetneſs, and the great variety of voice of which our artiſts have made it ſuſceptible, has withdrawn all farther attention from the clavichord, ſo that it is no longer probable that the learned contribution of the great Euler to public amuſement will be followed up. The Piano-forte correſponds to its name with great preciſion: For, without any other attention or effort than what ſentiment ſpontaneouſly dictates, and what we practiſe (without knowing it) on the harpſichord, where it is ineffectual, we make the Piano-forte give every gradation of ſtrength to the ſound of the ſtring, and give it every expreſſion that an inſtrument, purely pulſatile, is capable of. It is alſo ſuſceptible of a very conſiderable variety of tone by the clothing of the mallets, which may be acute or obtuſe, hard or ſoft. And we ſee, by the effect of what are called the grand Piano fortes, that they are fully equal to the harpſichord in fulneſs or body of tone. Nothing ſeems to be wanting to it but that ſliding, or (as the French call it) *careſſing* touch of the ſtring, by which a delicate finger, guided by fine taſte, cauſes the harp or lute to melt the heart, and excite its fineſt emotions. We truſt that the ingenuity of our Britiſh artiſts will accompliſh even this, and make this national inſtrument rival even the violin of Italy.

We call it a *national inſtrument*, not doubting but that this is a recommendation to a Britiſh heart, and becauſe we are very well aſſured that it is an Engliſh contrivance; the invention of a moſt excellent man and celebrated poet, Mr William Maſon. His Caractacus and Elfrida may convince any perſon who is a judge of muſic, that he had a mind exquiſitely ſenſible of all its charms; and we cannot be ſurpriſed that it was one of his chief delights. No man enjoyed the pleaſures of muſic with more rapture; and he uſed to ſay, that his ſpeedieſt recruit from the fatigue of a long walk was to ſit down for a few minutes to the harpſichord. He had ſeen ſeveral of the German attempts to make keyed dulcimers, which were, in ſome meaſure, ſuſceptible of the *forte* and *piano*: But they were all on one principle, and required a particular touch of the finger, of difficult acquiſition, and which ſpoiled it for harpſichord practice. We have alſo ſeen of thoſe inſtruments, ſome of very old date, and others of modern improvement. Some had very agreeable tones; but all were deficient in delicacy and juſtneſs. The performer was by no means certain of producing the very ſtrength of ſound that he intended. And, as Mr Maſon obſerved, they all required an artificial peculiarity of fingering; without which, either the intended ſtrength of tone was not brought out, or the tone was deſtroyed by repeated rattling of the mallet on the wire.

Mr Maſon removed all thoſe imperfections by detaching the mallet entirely from the key, and giving them a connection quite momentary. The ſketch in Plate XL. will give the reader a clear view of Mr Maſon's general principle, by which the Engliſh piano forte is diſtinguiſhed from all others. The parts are repreſented in their ſtate of inaction. The key ABK turns, as uſual, on the round edge of the bar B, and a pin *b*, driven into the bar, keeps it in its place. The dot F repreſents a ſection of the ſtring. ED is the mallet, having a hinge of vellum, by which it is attached to the upper ſurface of the bar E. At the other end is the head D, of wood, covered with ſome folds of prepared leather. The mallet lies in the poſition repreſented in the figure, its lower end reſting on a cuſhion-bar K, which lies horizontally under the whole row of mallets. The key AR has a pin C, tipt with a bit of the ſofteſt cork or buckſkin. This reaches to within $\frac{1}{10}$th of an inch of the ſhank of the mallet, but muſt not touch it. The diſtance E*e* is about $\frac{1}{3}$d or $\frac{1}{4}$th of the length of the ſhank. When the end A of the key is preſſed down on the ſtuffing (two or three thickneſſes of the moſt elaſtic woollen liſt) it raiſes the mallet, by means of the pin C, to the horizontal poſition E*d*, within $\frac{1}{8}$th or $\frac{1}{10}$th of an inch of the wire F; but it cannot be ſo much preſſed down as to make the mallet touch the wire. At the ſame time that the key raiſes the mallet by means of the pin C, it alſo lifts off the damper G (a bit of ſpunge) from the wire. This damper is fixed on the end of a little wooden pin G*g*, connected with the lever *g* H, which has a vellum hinge at H. This motion of the damper is cauſed by the pin I, which is fixed into the key near to R. Theſe pieces are ſo adjuſted, that the firſt touch of the key lifts the damper, and, immediately after, the pin C acts on the ſhank of the mallet. As it acts ſo near to its centre of motion, it cauſes the head D to move briſkly through a conſiderable arch D *d*. Being made extremely moveable, and very light, it is thus *toſſed* beyond the horizontal poſition E *d*, and it ſtrikes the wire F, which is now at liberty to vibrate up and down, by the previous removal of the damper G. Having made its ſtroke, the mallet falls down again, and reſts on the ſoft ſubſtance on the pin C. It is of eſſential importance that this mallet be extremely light. Were it heavy, it would have ſo much force, after rebounding from the wire, that it would rebound again from the pin C, and again ſtrike the wire. For it will be recollected, that the key is, at this time, down, and the pin C raiſed as high as poſſible, ſo that there is very little room for this rebound. Leſſening the momentum of the mallet by making it very light, making the cuſhion on the top of the pin C very ſoft, and great preciſion in the ſhape and figure of all the parts, are the only ſecurities againſt the diſagreeable rattling which theſe rebounds would occaſion. In reſpect to the ſolidity and preciſion of workmanſhip, the Britiſh inſtruments are unrivalled, and vaſt numbers of them are ſent to all parts of the continent.

As the blow of ſo light a mallet cannot bring much ſound from a wire, it has always been found neceſſary to have two ſtrings for each note. Another circumſtance contributes to enfeeble the ſound. The mechaniſm neceſſary for producing it makes it almoſt impoſſible to give any conſiderable extent to the belly or ſound board of the inſtrument. There is ſeldom any more of it than what occupies the ſpace between the tuning pins and the bridge. This is the more to be regretted, becauſe the baſſes are commonly covered ſtrings, that they may be of a moderate length. The baſs notes are alſo of braſs, which has a conſiderably lower tone than a ſteel wire of the ſame diameter and tenſion. Yet even this ſubſtitution for ſteel in the baſs ſtrings is not enough. The higheſt of them are much too ſlack, and the loweſt ones muſt be loaded, to compenſate for want of length. This greatly diminiſhes the fulneſs, and ſtill more the mellowneſs and diſtinctneſs of the tone, and frequently makes the very loweſt notes hardly appreciable. This inequality of tone about the middle of the inſtrument is ſomewhat diminiſhed by conſtructing the inſtrument with two bridges; one for the ſteel, and the other for the braſs wires. But ſtill the baſs notes are very much inferior to the treble. It would ſurely be worth while to conſtruct ſome piano fortes, of full ſize, with naked baſſes. If theſe were made with all the other advantages of the grand piano forte, they would ſurpaſs all other inſtruments for the regulating power of their thorough baſs. We wiſh that the artiſts would alſo try to conſtruct them with the mechaniſm of mallets, &c. above the ſound board. This would allow to it the full extent of the inſtrument, and greatly improve the tone. It does not ſeem impoſſible, nor (we think) very difficult.

For directions how to tune this pleaſing inſtrument, ſee TEMPERAMENT in this *Supplement*.

PIGMENTS, or PAINTS, are furniſhed by both the mineral and vegetable kingdoms. The former are the moſt durable, and are generally prepared from the OXYDS of metals (ſee CHEMISTRY *Index* in this *Suppl.* and *COLOUR-Making*, Encycl.); but Fourcroy thinks that chemiſtry furniſhes a method of fixing vegetable colours completely. From a number of experiments, which we need not detail, as they will be noticed in the article *Vegetable* SUBSTANCES, he draws the following concluſions:

1. That oxygen, when combined with vegetable ſubſtances, changes their colour.

2. That different proportions of this principle produce different ſhades in coloured vegetable matter.

3. That theſe ſhades paſs, by a ſort of degradation, from the darkeſt colours to the lighteſt; and that the extreme point of the latter may be conſidered as a complete deprivation of colour.

4. That in many vegetable ſubſtances this degradation does not take place, as M. Berthollet has obſerved.

5. That many red, violet, purple, cheſnut, and blue vegetable colours, are produced by different proportions of oxygen; but that none of theſe are completely ſaturated with this principle.

6. That the complete ſaturation here ſpoken of generally produces yellow colours, which are the leaſt changeable of all.

7. That vegetable ſubſtances coloured by oxygen, not only change their colour according to the proportion of oxygen they have imbibed, but that they alſo change their nature in the ſame proportion, and approach more to a reſinous ſtate as they become nearer to a yellow colour.

Laſtly, that the cauſe of the changeability of the red, brown, and violet colours, procured from vegetables, is ſuch as has been ſtated above; that there exiſts a method of fixing them, or rendering them permanent, by impregnating them with a certain quantity of oxygen, by means of the oxygenated muriatic acid; imitating, by this proceſs, the method purſued by nature, who never forms fixed and permanent colours, except in ſubſtances which have been long expoſed to the open air.

PITCH. See *Encycl.*—The beſt black pitch is made of the refuſe of roſin and turpentine, ſuch as will not paſs through the ſtraw filter, and the cuttings around the inciſion on the tree. Theſe materials are put into a boiler ſix or ſeven feet in circumference, and eight or ten high. Fuel is laid around the top, and the materials as they melt flow through a channel cut in the fire-place into a tub half filled with water. It is at that time very red, and almoſt liquid. To give this a proper conſiſtence, it is put in a cauldron placed in a furnace, and boiled down in the ſame manner as roſin, but it requires much leſs precaution and double the time. It is then poured into moulds of earth, and forms the beſt kind of black pitch. See ROSIN and TURPENTINE in this *Suppl.*

BASTARD PITCH, is a mixture of colophony, black pitch, and tar. They are boiled down together, and put into barrels of pine wood, forming, when the ingredients are mixed in equal portions, a ſubſtance of a very liquid conſiſtence, called in France *bray gras*. If, on the contrary, it is deſired of a thicker conſiſtence, a greater proportion of colophony is added, and it is caſt in moulds. It is then called *baſtard pitch*.

PLAGUE (ſee MEDICINE-*Index*, Encycl.), is a diſeaſe which has been lately aſſerted by Dr Moſeley to be not contagious. In ſupport of this opinion, he quotes many paſſages from medical writers, ancient and modern; but he ſeems to place the greateſt confidence (as is indeed natural) in his own obſervations on peſtilential fevers in the Weſt Indies, and on what is ſaid of the plague in Berthier's account of Buonaparte's expedition into Syria.

"At the time of our entry into Syria (ſays this Frenchman), all the towns were infected by the plague; a malady which ignorance and barbarity render ſo fatal in the Eaſt. Thoſe who are affected by it give themſelves up for dead: they are immediately abandoned by every body (A), and are left to die, when they might have been ſaved by medicine and attention.

"Citizen Degenettes, principal phyſician to the army, diſplayed a courage and character which entitle him to the national gratitude. When our ſoldiers were attacked by the leaſt fever, it was ſuppoſed that they had caught the plague, and theſe maladies were confounded. The fever hoſpitals were abandoned by the officers of health and their attendants. Citizen Degenettes repaired in perſon to the hoſpitals, viſited all the patients, felt the glandular ſwellings, dreſſed them, declared and maintained that the diſtemper was not the plague, but a malignant fever with glandular ſwellings, which might eaſily be cured by attention, and keeping the patient's mind eaſy."

Degenette's views in making this diſtinction were highly commendable; but certainly, ſays Dr Moſeley, this fever was the plague. The phyſician, however, carried his courage ſo far, as to make two inciſions, and to inoculate the ſuppurated matter from one of theſe buboes above his breaſt and under his arm-pits, but was not affected with the malady. He thus eaſed the minds of the ſoldiers, the firſt ſtep to a cure; and, by his aſſiduity and conſtant attendance in the hoſpitals, a number of men attacked with the plague were cured. His example was followed by other officers of health.

The lives of a number of men Citizen Degenettes was

(A) This can hardly be true. Every one knows that Mahometans are fataliſts in the ſtricteſt ſenſe of the word; and Mr Browne, whoſe knowledge of Syria and its inhabitants muſt be at leaſt equal to that of Berthier, aſſures us, that, far from abandoning his friend in the plague, "the Moſlem, awe-ſtruck, and reſigned to the unalterable decrees of fate, hangs over the couch of his expiring relative."

was thus inſtrumental of ſaving. He diſmiſſed thoſe who had been ill with the fever and buboes, without the leaſt contagion being communicated to the army.

"There are (ſays Dr Moſeley) annual or ſeaſonal diſorders, more or leſs ſevere, in all countries; but the plague, and other great depopulating epidemics, do not always obey the ſeaſons of the year. Like comets, their courſe is eccentric. They have their revolutions; but from whence they come, or whither they go after they have made their revolutions, no mortal can tell.

"To look for the cauſe of an epidemic in the preſent ſtate of the air, or weather, when it makes its appearance, is a very narrow contracted method of ſcrutiny. The cauſe of peſtilential epidemics cannnot be confined, and local. It muſt lie in the atmoſphere, which ſurrounds, and is in contact with every part of us; and in which we are immerſed, as bodies in fluids.

"Theſe diſeaſes not appearing in villages and thinly inhabited places, and generally attacking only great towns and cities, may be, that the atmoſphere, which I conceive to be the univerſal propagator of peſtilence, wants a commixture, or union, with ſome compounded and peculiar air, ſuch as is generated in populous communities, to releaſe its impriſoned virulence, and give it force. Like the divided ſeminal principles of many plants, concealed in winds and rains until they find ſuitable materials and ſoil to unite their ſeparated atoms, they then aſſume viſible forms in their own proper vegetation.

"Diſeaſes originating in the atmoſphere ſeize ſome, and paſs by others; and act excluſively on bodies graduated to receive their impreſſions; otherwiſe whole nations would be deſtroyed. In ſome conſtitutions of the body the acceſs is eaſy, in ſome difficult, and in others impoſſible.

"The air of confined places may be ſo vitiated as to be unfit for the purpoſes of the healthy exiſtence of any perſon. Hence gaol, hoſpital, and ſhip fevers. But as theſe diſtempers are the offspring of a local cauſe, that local cauſe, and not the diſtempered people, communicate the diſeaſe.

"Plagues and peſtilences, the produce of the great atmoſphere, are conveyed in the ſame manner, by the body being in contact with the cauſe; and not by its being in contact with the effect. If peſtilences were propagated by contagion, from infected perſons, the infection muſt iſſue from their breath or excrements, or from the exhalations of the bodies of the diſeaſed. The infection, if it were not in the atmoſphere, would be confined within very narrow limits; have a determinate ſphere of action; and none but phyſicians and attendants on the ſick would ſuffer; and theſe muſt ſuffer; and the cauſe and the effects would be palpable to our ſenſes. Upon this ground the precaution of quarantine would be rational. But who then would viſit and attend the ſick, or could live in hoſpitals, priſons, and lazarettos?"

From theſe reaſonings and facts, the author is convinced, that the bubo and carbuncle, of which we hear ſo much in Turkey, and read ſo much in our own hiſtory of plagues, ariſe from heating food and improper treatment; that they contain no infection; and conſequently that they are not the natural depoſit of the morbific virus ſeparated from the contagion.

He is equally confident that no peſtilential or pandemic fever was ever imported or exported; and hence he conſiders the fumigating of ſhip-letters, and ſhutting up the crews and paſſengers of veſſels, on their arrival from foreign places, ſeveral weeks, for fear they ſhould give diſeaſes to others which they have not themſelves, as an ignorant barbarous cuſtom. Whence was the importation of the plague at Naples in 1656; by which 20,000 people died in one day? Can any perſon, for a moment reflecting, believe, that the great plague of London in 1665, which imagination traced from the Levant to Holland, and from Holland to England, was cauſed by opening a bag of cotton in the city, or in Long Acre; or a package of hemp in St Giles's pariſh? Quarantine, always expenſive to commerce, and often ruinous to individuals, is a reflection on the good ſenſe of countries.

That Dr Moſeley is a man of learning, and a lively writer, is known to every one who has looked into his works, and is not himſelf a ſtranger to letters. On this account, and ſtill more on account of the opportunities which he has poſſeſſed of making accurate obſervations on various kinds of peſtilential diſeaſes, we have detailed at ſome length his notions of the plague; but as it does not appear that he ever *ſaw* the diſeaſe which is *known* by the name of *the plague*, juſtice requires that we give ſome account of it from a man who had the beſt poſſible opportunities of obtaining correct information on the ſubject.

"The facts that appear to be chiefly aſcertained relative to the plague (ſays Mr Browne), are, 1. That the infection is not received but by actual contact. In this particular, it would ſeem leſs formidable than ſeveral other diſorders. 2. That it is communicated by certain ſubſtances, by others not; as by a woollen cloth, or rope of hemp, but not by a piece of ivory, wood, or a rope made of the date tree; nor by any thing that has been completely immerſed in water. It would appear from the report of the Kahirines*, that no animal but man is affected with this diſorder; though, it is ſaid, a cat paſſing from an infected houſe has carried the contagion. 3. That perſons have often remained together in the ſame houſe, and entirely under the ſame circumſtances, of whom one has been attacked and died, and the others never felt the ſmalleſt inconvenience. 4. That a perſon may be affected any number of times. 5. That it is more fatal to the young than the old. 6. That no climate appears to be exempt from it; yet, 7. That the extremes of heat and cold both appear to be adverſe to it. In Conſtantinople it is often, but far from being always, terminated by the cold of winter, and in Kahira by the heat of ſummer; both circumſtances being, as may be conjectured, the effect of indiſpoſition for abſorption in the ſkin, unleſs it be ſuppoſed that in the latter caſe it may be attributed to the change the air undergoes from the increaſe of the Nile.

"The firſt ſymptoms are ſaid to be thirſt; 2. cephalalgia; 3. a ſtiff and uneaſy ſenſation, with redneſs and tumor about the eyes; 4. watering of the eyes; 5. White puſtules on the tongue. The more advanced ſymptoms of buboes, fœtor of the breath, &c. &c. are well known; and I have nothing authentic to add to them. Not uncommonly, all theſe have ſucceſſively ſhewn themſelves, yet the patient has recovered; in which caſe, where ſuppuration has had place, the ſkin always remains diſcoloured, commonly of a purple hue. Many who have been bleeded in an early ſtage of the diſorder, have recovered without any fatal ſymptoms; but whether from that or any other cauſe, does not appear certain (B). The ſame operation is reported to have been commonly fatal in a late ſtage. It is ſaid that embrocating the buboes continually with oil has ſometimes wrought a cure; but this remedy is ſo difficult and dangerous for the operator, that it would appear experiments muſt yet be very defective."

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* The inhabitants of Cairo, which Mr Brown uniformly calls *Kahira*.

They are not, perhaps, ſo defective as Mr Browne ſuppoſes. In the hoſpital of St Anthony at Smyrna, it has been the practice for many years paſt to rub over with warm olive oil the bodies of perſons infected by the plague; and that practice has been attended with wonderful ſucceſs. It was firſt ſuggeſted by Mr Baldwin the Engliſh conſul; and from him adopted by *P. Luigi di Pavia*, who for upwards of 27 years has expoſed himſelf to infection by his unremitting attendance on thoſe who are labouring under this dreadful diſtreſs. This excellent man, whoſe philanthropy equals that even of "Marſeilles' good biſhop," declares, that during the long period mentioned, he has found no remedy comparable to that of rubbing olive oil, with the ſtrongeſt friction, into the whole body of the infected perſon. When the body is thus rubbed, the pores being opened, imbibe the oil, and a profuſe perſpiration takes place, by which the poiſonous infection is again thrown out. This operation muſt be performed the firſt day of the infection; and if only a weak perſpiration enſues, it muſt be repeated till it is obſerved that every particle of infection is removed, and that the whole body of the patient is covered with a profuſe ſweat. Neither the patient's ſhirt nor bed-clothes muſt be changed till the perſpiration has entirely ceaſed. The operation muſt be performed in a very cloſe apartment; and at every ſeaſon of the year there muſt be kept in it a fire-pan, over which ſugar and juniper muſt be thrown from time to time, that the vapour which thence ariſes may promote the perſpiration. The whole body of the patient, the eyes alone excepted, muſt in this manner be anointed, or rather rubbed over with the greateſt care.

This practice of the pious monk is mentioned by Mr Howard in his work on Lazarettos; but a more ſatisfactory account of it is given by Count *Leopold von Berchtold*, who adds the following remarks by way of illuſtration: 1. The operation of rubbing in the oil muſt be performed by means of a ſponge, and ſo ſpeedily as not to laſt more than about three minutes. 2. The interval between the firſt and the ſecond rubbing, if a ſecond be neceſſary, muſt be determined by circumſtances, as the ſecond muſt not be performed till the firſt perſpiration is over, and this will depend on the conſtitution of the patient. If any ſweat remains upon the ſkin, it muſt be wiped off with a warm cloth before the ſecond rubbing takes place. This ſtrong friction with oil may be continued, for ſeveral days ſucceſſively, until a favourable change is remarked in the diſeaſe; after which the rubbing may be performed in a more gentle manner. The quantity of oil requiſite each time cannot be determined with accuracy; but, in general, a pound may be ſufficient. The pureſt and freſheſt oil is the beſt for this operation: it muſt not be hot, but only lukewarm. The breaſt and privities muſt be rubbed ſoftly. In a cold climate ſuch as ours, thoſe parts only into which the oil is rubbed muſt be expoſed naked. The other parts muſt be covered with warm clothing. In this manner each part of the body muſt be rubbed with oil in ſucceſſion, as quickly as poſſible, and be then inſtantly covered. If the patient has boils or buboes, they muſt be rubbed over gently with the oil till they can be brought to ſuppurate by means of emollient plaſters. The perſons who attend the patients to rub in the oil muſt take the precaution to rub themſelves over in the like manner, before they engage in the operation. They muſt, if poſſible, avoid the breath of the patient, and not be under any apprehenſions of catching the infection.

P. Luigi then ſays: "In order to prevent the patients from loſing their ſtrength, I preſcribed for them, during four or five days, ſoup made of vermicelli boiled in vinegar without ſalt. I gave them ſix or ſeven times a-day a ſmall ſpoonful of preſerved ſour cherries; preſerved not with honey, but with ſugar, as the former might have occaſioned a diarrhœa. When convinced that the patients were getting better, I uſually gave them the fifth morning a cup of good Mocha coffee, with a piece of toaſted biſcuit (*biſcotto*) prepared with ſugar; and I doubled the latter according to the ſtrength and improvement of my patients."

In the courſe of five years, during which friction with oil was employed in the hoſpital at Smyrna, of 250 perſons attacked by the plague the greater part were

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(B) Dr Moſeley, we think, has aſſigned a very ſufficient reaſon why bleeding ſhould generally prove effectual, if recourſe be had to it at the commencement of the diſeaſe. "In the common order of peſtilential fevers (ſays he), they commence with coldneſs and ſhivering; ſimply demonſtrating, that ſomething unuſual has been in contact with the ſkin, agonizing cutaneous ſenſibility. Sickneſs at the ſtomach, and an immoveable preſſure about the præcordia, follow. Theſe demonſtrate, that the blood cannot pervade the extremities of the body, and that the quantity which ought to dilate through the whole machine is confined to the larger organs, and is crowding and diſtending the heart and central veſſels.

"The reſtraining power of the remoter blood-veſſels being deſtroyed, the thinner parts of the blood eſcape their boundaries; hence ariſes yellowneſs in the ſkin in ſome climates; in others, the extravaſated groſſer parts of the blood ſtagnate, forming black lodgements, bubo, anthrax, and exanthemata.

"The object in theſe fevers is, to decide the conteſt between the ſolids and the fluids; and this appears to me to be only practicable, when ſpontaneous ſweats do not happily appear, or cannot be raiſed by a cooling regimen; and by draining the vital parts, by bleeding and purging, before the fluids have burſt their confines, and diſſolved their bond of union with the ſolids. The next ſtep is to regain the loſt energy of the ſurface of the body, by exciting perſpiration; and then of the whole ſyſtem, by tonics.

"When theſe things are not done in the firſt hours of attack, in peſtilential fevers, and the conflict is not *extinguiſhed* at once, attempting to extort ſweats from the body, by heating alexapharmics, will do miſchief; and bark, wine, ſtimulants, and cordials, may be called on, like undertakers, to perform an uſeleſs ceremony."

were cured; and this would have been the caſe with the reſt had they not neglected the operation, or had it not been employed too late after their nervous ſyſtem had been weakened by the diſeaſe ſo as to render them incurable. Immenſe numbers of people have been preſerved from the effects of this malady by the above means; and of all thoſe who have anointed themſelves with oil, and rubbed it well into their bodies, not one has been attacked by the plague, even though they approached perſons already infected, provided they abſtained from heavy and indigeſtible food.

Thus we ſee, if this account may be depended on, that oil rubbed into the ſkin acts as a preventative, as well as a cure. When the operation is performed to prevent infection, and it is ſucceſsfully performed with that view at Smyrna, as often as the plague makes its appearance in the city, as it is not done for the purpoſe of promoting perſpiration, it is not requiſite that it ſhould be performed with the ſame ſpeed as when for curing the diſorder; nor is it neceſſary to abſtain from fleſh and to uſe ſoups; but it will be proper to uſe only fowls or veal for ten or twelve days, boiled or roaſted, without any addition or ſeaſoning *(condimento)*. In the laſt place, it will be neceſſary to guard againſt fat and indigeſtible food, and ſuch liquors as might put in motion or inflame the maſs of the blood.

This important diſcovery deſerves the ſerious conſideration of all medical men; for if olive oil has been found efficacious in curing or preſerving againſt one ſpecies of infection, it is not abſurd to ſuppoſe that the ſame or other kinds of oil might be productive of much benefit in other malignant infectious diſeaſes. We hope ſoon to hear of ſome trial being made with it in this country. Would it be of any ſervice in the yellow fever, ſo prevalent in the weſtern world? See the *Philoſophical Magazine*, Vol. II.

PLANETARY HOURS, are twelfth parts of the artificial day and night; being each double in length to the hour uſed in civil computation in Europe. They are ſtill uſed by the Jews as they were among their forefathers; and hence are called *Jewiſh* hours. The reaſon of their being called *planetary* hours, is, that, according to the aſtrologers, a new planet comes to predominate every hour, and that the day takes its denomination from that which predominates the firſt hour of it; as Monday from the moon, &c.

PLANTS, organiſed bodies, of which a full account has been given in the *Encycl.* under the title BOTANY, PLANT, SEXES, &c. The eſtabliſhment of the ſexual ſyſtem in vegetables, and the acknowledged analogy between vegetable and animal bodies, has ſuggeſted a method of improving plants, as animals are confeſſedly improved, by what is called *croſſing the breed*. This thought occurred firſt, we believe, to Andrew Knight, Eſq; and in the Tranſactions of the Royal Society for 1799, we have an account of ſome very curious experiments made by him, with the view of aſcertaining whether the improvement which he had conceived be actually practicable. Thoſe were chiefly made on the garden pea, of which he had a kind growing in his yard; which having been long cultivated in the ſame ſoil, had ceaſed to be productive, and did not appear to recover the whole of its former vigour when removed to a ſoil of a ſomewhat different quality. On this his firſt experiment in 1787 was made. Having opened a dozen of its immature bloſſoms, he deſtroyed the male parts, taking great care not to injure the female ones; and a few days afterwards, when the bloſſoms appeared mature, he introduced the farina of a very large and luxuriant grey pea into one half of the bloſſoms, leaving the other half as they were. The pods of each grew equally well; but he ſoon perceived that of thoſe into whoſe bloſſoms the farina had not been introduced, the ſeed remained nearly as they were before the bloſſom expanded, and in that ſtate they withered. Thoſe in the other pods attained maturity, but were not in any ſenſible degree different from thoſe afforded by other plants of the ſame variety; owing, he imagines, to the external covering of the ſeed (as he had found in other plants) being furniſhed entirely by the female. In the ſucceeding ſpring, the difference, however, became extremely obvious; for the plants from them aroſe with exceſſive luxuriance, and the colour of their leaves and ſtems clearly indicated that they had all exchanged their whiteneſs for the colour of the male parent: the ſeeds produced in autumn were dark grey. By introducing the farina of another white variety (or in ſome inſtances by ſimple culture), he found this colour was eaſily diſcharged, and a numerous variety of new kinds produced; many of which were in ſize and every other reſpect much ſuperior to the original white kind, and grew with exceſſive luxuriance, ſome of them attaining the height of more than twelve feet.

The diſſimilarity he obſerved in the offspring, afforded by different kinds of farina in theſe experiments, pointed out to him an eaſy method of aſcertaining whether ſuperfœtation (the exiſtence of which has been admitted among animals) could alſo take place in the vegetable world. For as the offspring of a white pea is always white, unleſs the farina of a coloured kind be introduced into the bloſſom, and as the colour of the grey one is always transferred to its offspring, though the female be white, it readily occurred to Mr Knight, that if the farina of both were mingled or applied at the ſame moment, the offspring of each could be eaſily diſtinguiſhed.

His firſt experiment was not altogether ſucceſsful; for the offspring of five pods (the whole which eſcaped the birds) received their colour from the coloured male. There was, however, a ſtrong reſemblance to the other male in the growth and character of more than one of the plants; and the ſeeds of ſeveral in the autumn very cloſely reſembled it in every thing but colour. In this experiment he uſed the farina of a white pea, which poſſeſſed the remarkable property of ſhrivelling exceſſively when ripe; and in the ſecond year he obtained white ſeeds from the grey ones above mentioned, perfectly ſimilar to it. He is therefore ſtrongly diſpoſed to believe that the ſeeds were here of common parentage; but doth not conceive himſelf to be in poſſeſſion of facts ſufficient to enable him to ſpeak with deciſion on this queſtion. We have no right to form a decided opinion on this part of the ſubject, having paid to it very little attention; but at preſent we are inclined to think differently from the author. We admit, indeed, that if the female afford the firſt organized atom, and the male act only as a ſtimulus, it is by no means impoſſible that the exploſion of two veſicles of farina, at the ſame moment (taken from different plants), may afford ſeeds of common parentage; but whether the female or the male affords the firſt organized atom, is the queſtion which to us appears not yet decided.

Plants.

Another ſpecies, however, of ſuperfœtation, in which one ſeed appears to have been the offſpring of two males, has occurred to Mr Knight ſo often, as to remove, he ſays, all poſſibility of doubt as to its exiſtence. In 1797, the year after he had ſeen the reſult of the laſt mentioned experiment, having prepared a great many white bloſſoms, he introduced the farina of a white and that of a grey nearly at the ſame moment into each; and as in the laſt year the character of the coloured male had prevailed, he uſed its farina more ſparingly than that of the white one; and now almoſt every pod afforded plants of different colours. The majority, however, were white; but the characters of the two kinds were not ſufficiently diſtinct to allow him to judge with preciſion whether any of the ſeeds were produced of common parentage or not. In the year 1798 he was more fortunate; having prepared bloſſoms of the little early frame pea, he introduced its own farina, and immediately afterwards that of a very large and late grey kind, and ſowed the ſeeds thus obtained in the end of ſummer. Many of them retained the colour and character of the ſmall early pea, not in the ſlighteſt degree altered, and bloſſomed before they were eighteen inches high; whilſt others (taken from the ſame pods), whoſe colour was changed, grew to the height of more than four feet, and were killed by the froſt before any bloſſoms appeared.

It is evident, that in theſe inſtances ſuperfœtation took place; and it is equally evident that the ſeeds were not all of common parentage. Should ſubſequent experience evince, that a ſingle plant may be the offſpring of two males, the analogy between animal and vegetable nature may induce ſome curious conjectures relative to the proceſs of generation in the animal world.—It certainly may; but either we do not perfectly underſtand the author's meaning, or this experiment is not concluſive. There were here ſeeds of different colours produced by the farina of different males, operating on the ſame female plant; and there are well atteſted inſtances of twin children being born of different colours, in conſequence of the coition of different males, a negro and a white man, with the ſame woman. Had Mr Knight diſcovered, not that the ſame pod, but that the ſame individual *pea*, was the offſpring of two males, his diſcovery would indeed have led to ſome curious conjectures reſpecting animal generation. But to proceed with his experiments:

By introducing the farina of the largeſt and moſt luxuriant kinds into the bloſſoms of the moſt diminutive, and by reverſing this proceſs, he found that the powers of the male and female, in their effects on the offſpring, are exactly equal. The vigour of the growth, the ſize of the ſeeds produced, and the ſeaſon of maturity, were the ſame, though the one was a very early and the other a late variety. He had in this experiment a ſtriking inſtance of the ſtimulative effects of croſſing the breeds; for the ſmalleſt variety, whoſe height rarely exceeded two feet, was increaſed to ſix feet; whilſt the height of the large and luxuriant kind was very little diminiſhed. By this proceſs it is evident, that any number of new varieties may be obtained; and it is highly probable, that many of theſe will be found better calculated to correct the defects of different ſoils and ſituations than any we have at preſent.

The ſucceſs of Mr Knight's experiments on the pea induced him to make ſimilar experiments on wheat; but theſe did not anſwer his expectations. The varieties indeed which he obtained, eſcaped the blights of 1795 and 1796; but their qualities were not otherwiſe good, nor were they permanent. His experiments on the apple, the improvement of which was the firſt object of his attention, have, as far as he could judge from the cultivated appearance of trees which had not borne fruit when he wrote his memoir, been fully equal to his hopes. The plants which he obtained from his efforts to unite the good qualities of two kinds of apple, ſeem to poſſeſs the greateſt health and luxuriance of growth, as well as the moſt promiſing appearance in other reſpects. In ſome of theſe the character of the male appears to prevail; in others that of the female; and in others both appear blended, or neither is diſtinguiſhable. Theſe variations, which were often obſervable in the ſeeds taken from a ſingle apple, evidently ariſe from the want of permanence in the character of this fruit, when raiſed from ſeed. Many experiments of the ſame kind were tried on other plants; but it is ſufficient to ſay, that all tended to evince, that improved varieties of every fruit and of eſculent plants may be obtained by this proceſs, and that Nature intended that a ſexual intercourſe ſhould take place between neighbouring plants of the ſame ſpecies.

Plants, Platinum.

PLANTS, *Nutrition of*. This is a ſubject on which a variety of opinions has been entertained by modern chemiſts. Haſſenfratz conſiders carbon as the ſubſtance which nouriſhes vegetables. Ingenhouz, in his work on the nutrition of plants, publiſhed in 1797, endeavours to prove, that if carbon has any influence in this reſpect, it can be only in the ſtate of carbonic acid, as that acid is abſorbed and decompoſed by vegetables; while the ligneous carbon, furniſhed by Nature, produces no effect on the expanſion of plants. Mr A. Young has endeavoured to demonſtrate the ſame thing by experiments. M. Raſn, a Daniſh chemiſt, deſirous of diſcovering the truth amidſt theſe contradictory opinions, made, for three years, a ſeries of experiments; from which he concludes, by the expanſion, ſize, and colour of the plants employed, that carbon, either vegetable or animal, has a decided influence in the nouriſhment of vegetables. What is new, and particularly worthy of remark in theſe reſearches, is, that, according to M. Raſn, the carbonic acid produces exactly the ſame effect as charcoal of wood.

According to Mr Raſn, coal aſhes, on which the German and Engliſh farmers beſtow ſuch praiſe, deſtroy the plants if the ſoil contains an eighth part of that admixture. The leaves become faded, as if ſcorched, at the end of from fifteen to twenty days, and the plants themſelves die at the end of four or five weeks.

No ſeed germinates in oil. A ſingle grain of common ſalt, in 200 grains of water, is ſufficient to retard the vegetation of plants, and may even kill them if they are watered with that ſaline liquor.

Shavings of horn, next to infuſion animals, are the moſt favourable to vegetation: charcoal holds the third rank. For the truth of theſe opinions, ſee *Vegetable* SUBSTANCES in this *Suppl.*

PLATINUM, or PLATINA (See CHEMISTRY, *Suppl.* Part I. Chap. iii. Sect. 3.), is a metal, of which every chemiſt regrets the difficulty of making it malleable. Of the different proceſſes adopted to accompliſh this end, we have reaſon to believe that of Mr Richard Knight the moſt ſucceſsful; and, with the ſpirit of a true philoſopher, he wiſhes to make that proceſs as generally known as poſſible. We ſhall give it in his own words:

"To a given quantity of crude platinum, I add (ſays he) 15 times its weight of nitro-muriatic acid (compoſed of equal parts of nitric and muriatic acids) in a tubulated glaſs retort, with a tubulated receiver adapted to it. It is then boiled, by means of an Argand's lamp, till the acid has aſſumed a deep ſaffron colour: it is then poured off; and if any platina remains undiſſolved, more acid is added, and it is again boiled until the whole is taken up. The liquor, being ſuffered to reſt till quite clear, is again decanted: a ſolution of ſal-ammoniac is then added, by little and little, till it no longer gives a cloudineſs. By this means the platina is thrown down in the form of a lemon-coloured precipitate, which having ſubſided, the liquor is poured off, and the precipitate repeatedly waſhed with diſtilled water till it ceaſes to give an acid taſte (too much water is injurious, the precipitate being in a certain degree ſoluble in that liquid); the water is then poured off, and the precipitate evaporated to dryneſs."

Thus far our author's method, as he candidly obſerves himſelf, differs not from that which has been followed by many others; but the remainder of the proceſs is his own. "A ſtrong, hollow, inverted cone of crucible earth being procured, with a correſponding ſtopper to fit it, made of the ſame materials, the point of the latter is cut off about three-fourths from the baſe. The platina, now in the ſtate of a light yellow powder, is preſſed tight into the cone, and, a cover being fixed ſlightly on, it is placed in an air-furnace, and the fire raiſed gradually to a ſtrong white heat. (The furnace uſed by Mr Knight is portable, with a chamber for the fire only eight inches in diameter.) In the mean time the conical ſtopper, fixed in a pair of iron tongs ſuitable for the purpoſe, is brought to a red, or to a bright red, heat. The cover being then removed from the cone, the tongs with the heated ſtopper is introduced through a hole in the cover of the furnace, and preſſed at firſt gently on the platina, at this time in a ſtate nearly as ſoft as dough, till it at length acquires a more ſolid conſiſtence. It is then repeatedly ſtruck with the ſtopper, as hard as the nature of the materials will admit, till it appears to receive no farther impreſſion. The cone is then removed from the furnace; and being ſtruck lightly with a hammer, the platina falls out in a metallic button, from which ſtate it may be drawn, by repeatedly heating and gently hammering, into a bar fit for flatting, drawing into wire, planiſhing, &c.

"Beſides the comparative facility of this proceſs, it has the farther advantage of rendering the platina much purer than when red-hot iron is obliged to be had recourſe to; for platina, when of a white heat, has a ſtrong affinity for iron, and, with whatever care it may have been previouſly ſeparated from that metal, will be found to have taken up a portion of it, when it is employed of a red heat, to ſerve to unite the particles of the platina."

PLATONIC Bodies, ſee *Regular Bodies*, *Suppl.*

PLUVIAMETER, a machine for meaſuring the quantity of rain that falls, otherwiſe called Ombrometer; which ſee, *Encycl.*

POLLARDS, the name of a coarſe kind of wheaten flour. When the flour of wheat is ſeparated into three degrees of fineneſs, the third is the pollards. There is nothing between it and the bran.

PORCELAIN, a kind of earthen or ſtone ware, of the manufacture of which a full account is given in the *Encyclopædia* from Groſier and Reaumur. It may be proper, however, to add here, from Sir George Staunton, that one of the principal ingredients in the Chineſe porcelain called *pe-tun-tſe*, is a ſpecies of fine granite, or compound of quartz, feldſpath, and mica, in which the quartz bears the largeſt proportion. "It appears (ſays Sir George) from ſeveral experiments, that *pe-tun-tſe* is the ſame as the growan-ſtone of the Corniſh miners. The micaceous part in ſome of this granite from both countries, often contains ſome particles of iron; in which caſe it will not anſwer the potter's purpoſe. This material can be calcined and ground much finer by the improved mills of England, than by the very imperfect machinery of the Chineſe, and at a cheaper rate, than the prepared *pe-tun-tſe* of their own country, notwithſtanding the cheapneſs of labour there. The *kao-lin*, or principal matter mixed with the *pe-tun-tſe*, is the growan-clay alſo of the Corniſh miners. The *wha-ſhe* of the Chineſe is the Engliſh ſoap rock; and the *ſhe-kan* is aſſerted to be gypſum.

"The manufacture of porcelain is ſaid to be precarious, from the want of ſome preciſe method of aſcertaining and regulating the heat within the furnaces, in conſequence of which, their whole contents are baked ſometimes into one ſolid and uſeleſs maſs." If this be ſo, Wedgewood's thermometer would be a preſent highly valuable to the Chineſe potter, if that arrogant and conceited people would condeſcend to be taught by a native of Europe.

POSITION, Centre of, is a point of any body, or ſyſtem of bodies, ſo ſelected, that we can eſtimate with propriety the ſituation and motion of the body or ſyſtem by the ſituation and motion of this point. It is very plain that, in all our attempts to accurate diſcuſſion of mechanical queſtions, eſpecially in the preſent extended ſenſe of the word *mechaniſm*, ſuch a ſelection is neceſſary. Even in common converſation, we frequently find it neceſſary to aſcertain the diſtance of objects with a certain preciſion, and we then perceive that we muſt make ſome ſuch ſelection. We conceive the diſtance to be mentioned, neither with reſpect to the neareſt nor the remoteſt point of the object, but as a ſort of average diſtance; and we conceive the point ſo aſcertained to be ſomewhere about the middle of the object. The more we reflect on this, we find it the more neceſſary to attend to many circumſtances which we had overlooked. Were it the queſtion, to decide in what preciſe part of a country pariſh the church ſhould be placed, we find that the geometrical middle is not always the moſt proper. We muſt conſider the populouſneſs of the different quarters of the pariſh, and ſelect a point ſuch, that the diſtances of the inhabitants on each ſide, in every direction, ſhall be as equally balanced as poſſible.

In mechanical diſcuſſions, the point by whoſe poſition and diſtance we eſtimate the poſition and diſtance of the whole, muſt be ſo ſelected, that its poſition and diſtance, eſtimated in any direction whatever, ſhall be the average of the poſitions and diſtances of every particle of the aſſemblage, eſtimated in that direction.

This will be the caſe, if the point be ſo ſelected that, when a plane is made to paſs through it *in any direc-*

Poſition.

tion whatever, and perpendiculars are drawn to this plane from every particle in the body or ſyſtem, the ſum of all the perpendiculars on one ſide of this plane is equal to the ſum of all the perpendiculars on the other ſide. If there be ſuch a point in a body, the poſition and motion of this point is the average of the poſitions and motions of all the particles.

Plate XL.

For if P (fig. 1.) be a point ſo ſituated, and if QR be a plane (perpendicular to the paper) at any diſtance from it, the diſtance P*p* of the point from this plane is the average of the diſtances of all the particles from it. For let the plane APB be paſſed through P, parallel to QR. The diſtance CS of any particle C from the plane QR is equal to DS − DC, or to P*p* − DC. And the diſtance GT of any particle G, lying on the other ſide of APB, is equal to HT + GH, or to P*p* + GH. Let *n* be the number of particles on that ſide of AB which is neareſt to QR, and let *o* be the number of thoſe on the remote ſide of AB, and let *m* be the number of particles in the whole body, and therefore equal to $n+o$. It is evident that the ſum of the diſtances of all the particles, ſuch as C, is *n* times P*p*, after deducting all the diſtances, ſuch as DC. Alſo the ſum of all the diſtances of the particles, ſuch as G, is *o* times P*p*, together with the ſum of all the diſtances, ſuch as GH. Therefore the ſum of both ſets is $\overline{n+o}\times Pp$ + ſum of GH — ſum of DC, or $m\times Pp$ + ſum of GH — ſum of DC. But the ſum of GH, wanting the ſum of DC, is nothing, by the ſuppoſed property of the point P. Therefore $m\times Pp$ is the ſum of all the diſtances, and P*p* is the *m*th part of this ſum, or the average diſtance.

Now ſuppoſe that the body has changed both its place and its poſition with reſpect to the plane QR, and that P (fig. 2.) is ſtill the ſame point of the body, and $\alpha P\beta$ a plane parallel to QR. Make $p\pi$ equal to *p*P of fig. 1. It is plain that P*p* is ſtill the average diſtance, and that $m\times Pp$ is the ſum of all the preſent diſtances of the particles from QR, and that $m\times \pi p$ is the ſum of all the former diſtances. Therefore $m\times P\pi$ is the ſum of all the changes of diſtance, or the whole quantity of motion eſtimated in the direction πP. Pπ is the *m*th part of this ſum, and is therefore the average motion in this direction. The point P has therefore been properly ſelected; and its poſition, and diſtance, and motion, in reſpect of any plane, is a proper repreſentation of the ſituation and motion of the whole.

It follows from the preceding diſcuſſion, that if any particle C (fig. 1.) moves from C to N, in the line CS, the centre of the whole will be transferred from P to Q, ſo that PQ is the *m*th part of CN; for the ſum of all the diſtances has been diminiſhed by the quantity CN, and therefore the average diſtance muſt be diminiſhed by the *m*th part of CN, or PQ is $=\frac{CN}{m}$.

But it may be doubted whether there is in every body a point, and but one point, ſuch that if a plane paſs through it, *in any direction whatever*, the ſum of all the diſtances of the particles on one ſide of this plane is equal to the ſum of all the diſtances on the other.

It is eaſy to ſhew that ſuch a point may be found, with reſpect to a plane parallel to QR. For if the ſum of all the diſtances DC exceed the ſum of all the diſtances GH, we have only to paſs the plane AB a little nearer to QR, but ſtill parallel to it. This will diminiſh the ſum of the lines DC, and increaſe the ſum of the lines GH. We may do this till the ſums are equal.

In like manner we can do this with reſpect to a plane LM (alſo perpendicular to the paper), perpendicular to the plane AB. The point wanted is ſomewhere in the plane AB, and ſomewhere in the plane LM. Therefore it is ſomewhere in the line in which theſe two planes interſect each other. This line paſſes through the point P of the paper where the two lines AB and LM cut each other. Theſe two lines repreſent planes, but are, in fact, only the interſection of thoſe planes with the plane of the paper. Part of the body muſt be conceived as being above the paper, and part of it behind or below the paper. The plane of the paper therefore divides the body into two parts. It may be ſo ſituated, therefore, that the ſum of all the diſtances from it to the particles lying above it ſhall be equal to the ſum of all the diſtances of thoſe which are below it. Therefore the ſituation of the point P is now determined, namely, at the common interſection of three planes perpendicular to each other. It is evident that this point alone can have the condition required in reſpect of theſe three planes.

But it ſtill remains to be determined whether the ſame condition will hold true for the point thus found, in reſpect to *any other* plane paſſing through it; that is, whether the ſum of all the perpendiculars on one ſide of *this fourth* plane is equal to the ſum of all the perpendiculars on the other ſide. Therefore

Let AGHB (fig. 3.), AKYB, and CDFE, be three planes interſecting each other perpendicularly in the point C; and let CIKL be any other plane, interſecting the firſt in the line CI, and the ſecond in the line CL. Let P be any particle of matter in the body or ſyſtem. Draw PM, PO, PR, perpendicular to the firſt three planes reſpectively, and let PR, when produced, meet the oblique plane in V; draw MN, ON, perpendicular to CB. They will meet in one point N. Then PMNO is a rectangular parallelogram. Alſo draw MQ perpendicular to CE, and therefore parallel to AB, and meeting CI in S. Draw SV; alſo draw ST perpendicular to VP. It is evident that SV is parallel to CL, and that STRQ and STPM are rectangles.

All the perpendiculars, ſuch as PR, on one ſide of the plane CDFE, being equal to all thoſe on the other ſide, they may be conſidered as compenſating each other; the one being conſidered as poſitive or additive quantities, the other are negative or ſubtractive. There is no difference between their ſums, and the ſum of both ſets may be called 0 or nothing. The ſame muſt be affirmed of all the perpendiculars PM, and of all the perpendiculars PO.

Every line, ſuch as RT, or its equal QS, is in a certain invariable ratio to its correſponding QC, or its equal PO. Therefore the poſitive lines RT are compenſated by the negative, and the ſum total is nothing.

Every line, ſuch as TV, is in a certain invariable ratio to its correſponding ST, or its equal PM, and therefore their ſum total is nothing.

Therefore the ſum of all the lines PV is nothing; but each is in an invariable ratio to a correſponding perpendicular from P on the oblique plane CIKL. Therefore the ſum of all the poſitive perpendiculars on this plane is equal to the ſum of all the negative perpendiculars, and the propoſition is demonſtrated, viz. that in every body, or ſyſtem of bodies, there is a point ſuch, that if a plane be paſſed through it *in any direction whatever*, the ſum of all the perpendiculars on one ſide of the plane is equal to the ſum of all the perpendiculars on the other ſide.

The point P, thus ſelected, may, with great propriety, be called the CENTRE OF POSITION of the body or ſyſtem.

If A and B (fig. 4.) be the centres of poſition of two bodies, whoſe quantities of matter (or numbers of equal particles) are a and b, the centre C lies in the ſtraight line joining A and B, and $AC : CB = b : a$, or its diſtance from the centres of each are inverſely as their quantities of matter. For let $\alpha C \beta$ be any plane paſſing through C. Draw $A\alpha$, $B\beta$, perpendicular to this plane. Then we have $a \times A\alpha = b \times B\beta$, and $A\alpha : B\beta = b : a$, and, by ſimilarity of triangles, $CA : CB = b : a$.

If a third body D, whoſe quantity of matter is d, be added, the common centre of poſition E of the three bodies is in the ſtraight line DC, joining the centre D of the third body with the centre C of the other two, and $DE : EC = a + b : d$. For, paſſing the plane $\delta E \kappa$ through E, and drawing the perpendiculars $D\delta$, $C\kappa$, the ſum of the perpendiculars from D is $d \times D\delta$; and the ſum of the perpendiculars from A and B is $\overline{a+b} \times C\kappa$, and we have $d \times D\delta = \overline{a+b} \times C\kappa$; and therefore $DE : EC = a + b : d$.

In like manner, if a fourth body be added, the common centre is in the line joining the fourth with the centre of the other three, and its diſtance from this centre and from the fourth is inverſely as the quantities of matter; and ſo on for any number of bodies.

If all the particles of any ſyſtem be moving uniformly, in ſtraight lines, in any directions, and with any velocities whatever, the centre of the ſyſtem is either moving uniformly in a ſtraight line, or is at reſt.

For, let m be the number of particles in the ſyſtem. Suppoſe any particle to move uniformly in any direction. It is evident from the reaſoning in a former paragraph, that the motion of the common centre is the mth part of this motion, and is in the ſame direction. The ſame muſt be ſaid of every particle. Therefore the motion of the centre is the motion which is compounded of the mth part of the motion of each particle. And becauſe each of theſe was ſuppoſed to be uniform and rectilineal, the motion compounded of them all is alſo uniform and rectilineal; or it may happen that they will ſo compenſate each other that there will be no diagonal, and the common centre will remain at reſt.

Cor. 1. If the centres of any number of bodies move uniformly in ſtraight lines, whatever may have been the motions of each particle of each body, by rotation or otherwiſe, the motion of the common centre will be uniform and rectilineal.

Cor. 2. The quantity of motion of ſuch a ſyſtem is the ſum of the quantities of motion of each body, reduced to the direction of the centre's motion. And it is had by multiplying the quantity of matter in the ſyſtem by the velocity of the centre.

The velocity of the centre is had by reducing the motion of each particle to the direction of the centre's motion, and then dividing the ſum of thoſe reduced motions by the quantity of matter in the ſyſtem.

By the ſelection of this point, we render the inveſtigation of the motions and actions of bodies incomparably more ſimple and eaſy, freeing our diſcuſſions from numberleſs intricate complications of motion, which would frequently make our progreſs almoſt impoſſible.

POSITION, in arithmetic, called alſo *Falſe Poſition*, or *Suppoſition*, or *Rule of Falſe*, is a rule ſo called, becauſe it conſiſts in calculating by falſe numbers ſuppoſed or taken at random, according to the proceſs deſcribed in any queſtion or problem propoſed, as if they were the true numbers, and then from the reſults, compared with that given in the queſtion, the true numbers are found.

Thus, take or aſſume any number at pleaſure for the number ſought, and proceed with it as if it were the true number, that is, perform the ſame operations with it as, in the queſtion, are deſcribed to be performed with the number required: then if the reſult of thoſe operations be the ſame with that mentioned or given in the queſtion, the ſuppoſed number is the ſame as the true one that was required; but if it be not, make this proportion, *viz.* as your reſult is to that in the queſtion; ſo is your ſuppoſed falſe number to the true one required.

Example. What number is that, to which if we add $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, and $\frac{1}{6}$ of itſelf, the ſum will be 240?

Suppoſe 99
49.5 $= \frac{1}{2}$
33. $= \frac{1}{3}$
24.75 $= \frac{1}{4}$
16.5 $= \frac{1}{6}$
222.75 = reſult

Then, as 222.75 : 240 : : 99 : $106.\dot{6}$ = Anſwer.
$53.\dot{3} = \frac{1}{2}$
$35.\dot{5} = \frac{1}{3}$
$26.\dot{6} = \frac{1}{4}$
$17.\dot{7} = \frac{1}{6}$
240. = proof.

This is *ſingle* poſition.

Sometimes it is neceſſary to make two different ſuppoſitions or aſſumptions, when the ſame operations muſt be performed with each as in the ſingle rule. If neither of the ſuppoſed numbers ſolve the queſtion, find the differences between the reſults and the given number; multiply each of theſe differences into the other's poſition; and if the errors in both ſuppoſitions be of the ſame kind, *i. e.* if both ſuppoſitions be either leſs or greater than the given number, divide the differences of the products by the differences of the errors. If the errors be not of the ſame kind, *i. e.* if the one be greater and the other leſs than the given number, divide the ſum of the products by the ſum of the errors. The quotient, in either caſe, will be the anſwer.

Example. Three partners, A, B, and C, bought a ſugar-work which coſt them L. 2000; of which A paid a certain ſum unknown; B paid as much as [illegible], and L. 50 over; C paid as much as them both, and L. 25 over: What ſum did each pay?

(1.) Suppoſe A paid L. 500
B —— 550
C —— 1075
2125
2000
125 = error of exceſs.

(2.) Suppoſe A paid L. 400
B —— 450
125 = exceſs. C —— 875
——
400 = 2d poſition. 1725
—— 2000
50000 ——
275 = error of defect.
500 = 1ſt poſition.
——
1ſt error, 125 137500
2d —— 275 50000
—— ——
400)187500
——
Anſwers. { 468.75 = ſum paid by A.
518.75 = ———— B.
1012.5 = ———— C.
——
2000. . . = proof.

This is called double poſition.

POTTERY is an art of very conſiderable importance; and in addition to what has been ſaid on it in the *Encyclopædia*, the following reflections, by that eminent chemiſt Vauquelin, will probably be acceptable to many of our readers.

Four things (ſays he) may occaſion difference in the qualities of earthen-ware: *1ſt*, The nature or compoſition of the matter; *2d*, The mode of preparation; *3d*, The dimenſions given to the veſſels; *4th*, The baking to which they are ſubjected. By compoſition of the matter, the author underſtands the nature and proportions of the elements of which it is formed. Theſe elements, in the greater part of earthen-ware, either valuable or common, are ſilex, argil, lime, and ſometimes a little oxyd of iron. Hence it is evident that it is not ſo much by the diverſity of the elements that good earthen-ware differs from bad, as by the proportion in which they are united. Silex or quartz makes always two-thirds at leaſt of earthen-ware; argil or pure clay, from a fifth to a third; lime, from 5 to 20 parts in the hundred; and iron, from 0 to 12 or 15 parts in the hundred. Silex gives hardneſs, infuſibility, and unalterability; argil makes the paſte pliable, and renders it fit to be kneaded, moulded, and turned at pleaſure. It poſſeſſes at the ſame time the property of being partially fuſed by the heat which unites its parts with thoſe of the ſilex; but it muſt not be too abundant, as it would render the earthen-ware too fuſible and too brittle to be uſed over the fire.

Hitherto it has not been proved by experience that lime is neceſſary in the compoſition of pottery: and if traces of it are conſtantly found in that ſubſtance, it is becauſe it is always mixed with the other earths, from which the waſhings and other manipulations have not been able to ſeparate it. When this earth, however, does not exceed five or ſix parts in a hundred, it appears that it is not hurtful to the quality of the pottery; but if more abundant, it renders it too fuſible.

The oxyd of iron, beſides the inconvenience of communicating a red or brown colour, according to the degree of baking, to the veſſels in which it forms a part, has the property of rendering them fuſible, and even in a greater degree than lime.

As ſome kinds of pottery are deſtined to melt very penetrating ſubſtances, ſuch as ſalts, metallic oxyds, glaſs, &c. they require a fine kind of paſte, which is obtained only by reducing the earths employed to very minute particles. Others deſtined for melting metals, and ſubſtances not very penetrating, and which muſt be able to ſupport, without breaking, a ſudden tranſition from great heat to great cold, require for their fabrication a mixture of calcined argil with raw argil. By theſe means you obtain pottery, the coarſe paſte of which reſembles *brecbe*, or ſmall-grained pudding-ſtone, and which can endure ſudden changes of temperature.

The baking of pottery is alſo an object of great importance. The heat muſt be capable of expelling humidity, and agglutinating the parts which enter into the compoſition of the paſte, but not ſtrong enough to produce fuſion; which, if too far advanced, gives to pottery a homogenuouſneſs that renders it brittle. The ſame effect takes place in regard to the fine pottery, becauſe the very minute diviſion given to the earths reduces them nearly to the ſame ſtate as if this matter had been fuſed. This is the reaſon why porcelain ſtrongly baked is more or leſs brittle, and cannot eaſily endure alternations of temperature. Hence coarſe porcelain, in the compoſition of which a certain quantity of calcined argil is employed, porcelain retorts, crucibles, tubes, and common pottery, the paſte of which is coarſe, are much leſs brittle than diſhes and ſaucers formed of the ſame ſubſtance, ground with more labour.

The general and reſpective dimenſions of the different parts of veſſels of earthen-ware have alſo conſiderable influence on their capability to ſtand the fire.

In ſome caſes the glazing or covering, eſpecially when too thick, and of a nature different from the body of the pottery, alſo renders them liable to break. Thus, in making ſome kinds of pottery, it is always eſſential, *1ſt*, To follow the beſt proportion in the principles; *2d*, To give to the particles of the paſte, by grinding, a minuteneſs ſuited to the purpoſe for which it is intended, and to all the parts the ſame dimenſions as far as poſſible; *3d*, To carry the baking to the higheſt degree that the matter can bear without being fuſed; *4th*, To apply the glazing in thin layers, the fuſibility of which ought to approach as near as poſſible to that of the matter, in order that it may be more intimately united.

C. Vauquelin, being perſuaded that the quality of good pottery depends chiefly on uſing proper proportions of the earthy matters, thought it might be of importance, to thoſe engaged in this branch of manufacture, to make known the analyſis of different natural clays employed for this purpoſe, and of pottery produced by ſome of them, in order that, when a new earth is diſcovered, it may be known by a ſimple analyſis whether it will be proper for the ſame object, and to what kind of pottery already known it bears the greateſt reſemblance.

	Heſſian Crucibles.	Argil of Dreux.	Porcelain Capſules.	Wedgewood's Pyrometers.
Silex	69	43·5	61	64·2
Argil	21·5	33·2	28	25
Lime	1	3·5	6	6
Oxyd of iron	8	1	0·5	0·2
Water		18		6·2

Raw kaolin 100 parts.—Silex 74, argil 16·5, lime 2, water 7. A hundred parts of this earth gave eight of alum, after being treated with the ſulphuric acid.

Waſhed kaolin 100 parts.—Silex 55, argil 27, lime 2, iron 0·5, water 14. This kaolin, treated with the ſulphuric acid, gave about 45 or 50 *per cent.* of alum.

Petuntzé.—Silex 74, argil 14·5, lime 5·5, loſs 6. A hundred parts of this ſubſtance, treated with the ſulphuric acid, gave ſeven or eight parts of alum. But this quantity does not equal the loſs ſuſtained.

Porcelain of retorts.—Silex 64, argil 28·8, lime 4·55, iron 0·50, loſs 2·77. Treated with the ſulphuric acid, this porcelain gave no alum.

There is a kind of earthen veſſels, called *Alcarrezas*, uſed in Spain for cooling the water intended to be drunk. Theſe veſſels conſiſt of 60 parts of calcareous earth, mixed with alumina and a little oxyd of iron, and 36½ of ſiliceous earth, alſo mixed with alumina and the ſame oxyd. The quantity of iron may be eſtimated at almoſt one hundredth part of the whole. This earth is firſt kneaded into a tough paſte, being for that purpoſe previouſly diluted with water; formed into a cake of about ſix inches in thickneſs, and left in that ſtate till it begin to crack. It is then kneaded with the feet, the workman gradually adding to it a quantity of ſea-ſalt, in the proportion of ſeven pounds to a hundred and fifty; after which it is applied to the lath, and baked in any kind of furnace uſed by potters. The alcarrezes, however, are only about half as much baked as the better kinds of common earthen ware; and being exceedingly porous, water oozes through them on all ſides. Hence the air, which comes in contact with it by making it evaporate, carries off the caloric contained in the water in the veſſel, which is thus rendered remarkably cool.

POULES, or Foulques, one of the principal nations which inhabit the banks of the Senegal. They poſſeſs an extent of more than ſixty leagues along the river, and exact heavy cuſtoms from the Senegal traders with the interior of the country. They are not ſo black as the other negroes, but of a copper colour, much inclining to red. It is remarkable, however, that their children who are ſent to Senegal, and reſide there for ſome years, become much blacker. The females are very handſome, and the whites of Senegal generally take care to procure ſome of them. But they are of a bad diſpoſition, and utterly incapable of attachment. When a man has a miſtreſs of this nation, he muſt watch her conduct very narrowly, and even chaſtiſe her, that ſhe may not be guilty of infidelity to him whom ſhe honours with her favours. The dread of the baſtinado will, in ſuch caſe, effect what attention and complaiſance can never bring about.

Although the Poules inhabit one of the fineſt ſpots in Africa, they are nevertheleſs a wretched people; they are baſe, cruel, thieviſh, and fanatic in the extreme. They are commanded by a chief of their religion, which is a contemptible mixture of Mahometaniſm and idolatry. This chief is called the *Almamy;* he is always choſen from among the Tampſirs, who are twelve in number. The Tampſirs are the interpreters of the law, and are the moſt learned, or rather the moſt fanatical among them. The Almamy has the power of life and death over his ſubjects; yet he may be depoſed by an aſſembly of Tampſirs: it is therefore his intereſt to keep on good terms with them. The payment of cuſtoms is made to the Almamy, and is afterwards diſtributed among the Tampſirs; and although a part belongs to the former, he nevertheleſs requires a ſeparate preſent for himſelf.

PRINTING. (See that article, *Encycl.* and Typography in this *Supplement.*) We ſhall here only deſcribe a *Printing-Preſs*, for the invention of which a patent was granted, in 1790, to Mr William Nicholſon of New North-ſtreet, Red Lion Square, London. This machine, with ſome ſlight varieties, is adapted for printing on *paper, linen, cotton, woollen*, and other articles, in a more neat, cheap, and accurate method, the author thinks, than the printing preſſes now in uſe.

The invention conſiſts in three particulars, *1ſt*, The manner of preparing and placing the types, engravings, or carvings, from which the impreſſion is to be made; *2dly*, In applying the ink or colouring matter to types or engravings; and, *3dly*, In taking off the impreſſion.

1ſt, Mr Nicholſon makes his moulds, punches, and matrices, for caſting letters, in the ſame manner, and with the ſame materials, as other letter-founders do, excepting that, inſtead of leaving a ſpace in the mould for the ſtem of one letter only, he leaves ſpaces for two, three, or more letters, to be caſt at one pouring of the metal; and at the lower extremity of each of thoſe ſpaces (which communicate by a common groove at top) he places a matrix, or piece of copper, with the letter punched upon its face in the uſual way. And moreover, he brings the ſtem of his letters to a due form and finiſh, not only by rubbing it upon a ſtone, and ſcraping it when arranged in the finiſhing-ſtick, but likewiſe by ſcraping it, on one or more ſides, in a finiſhing-ſtick whoſe hollowed part is leſs deep at the inner than the outer ſide. He calls that ſide of the groove which is neareſt the face of the diſpoſed letter, the outer ſide; and the purpoſe accompliſhed by this method of ſcraping is, that of rendering the tail of the letter gradually ſmaller the more remote it is, or farther from the face. Such letters may be firmly impoſed upon a cylindrical ſurface, in the ſame manner as common letters are impoſed upon a flat ſtone.

2dly, He applies the ink or colouring matter to the types, forms, or plates, by cauſing the ſurface of a cylinder, ſmeared or wetted with the colouring matter, to roll over the ſurfaces of the ſaid forms or plates, or by cauſing the forms or plates apply themſelves ſucceſſively to the ſurface of the cylinder. The ſurface of this colouring cylinder is covered with leather, or with woollen, linen, or cotton-cloth. When the colour to be uſed is thin, as in calico-printing, and in almoſt every caſe, the covering is ſupported by a firm elaſtic ſtuffing, conſiſting of hair, or wool, or woollen cloth wrapped one or more folds round the cylinder. When the covering conſiſts of woollen cloth, the ſtuffing muſt be defended by leather, or oilſkin, to prevent its imbibing too much colour, and by that means loſing its elaſticity. It is abſolutely neceſſary that the colouring matter be evenly diſtributed over the ſurface of the cylinder; and for this purpoſe, when the colour is thick and ſtiff, as in letter-preſs printing, he applies two, three, or more ſmall cylinders, called diſtributing-rollers, longitudinally againſt the colouring cylinders, ſo that they may be turned by the motion of the latter; and the effect of this application is, that every lump or maſs of colour which may be redundant, or irregularly placed upon the face of the colouring cylinder, will be preſſed, ſpread, and partly taken up, and carried by the ſmall rollers to the other parts of the colouring cylinder; ſo that this laſt will very ſpeedily acquire and preſerve an even face of colour. But if the colouring matter be thinner, he does not apply more than one or two of theſe diſtributing-rollers; and, if it be very thin, he applies an even blunt edge of metal, or wood, or a ſtraight bruſh, or both of theſe laſt, againſt the colouring cylinder, for the purpoſe of rendering its colour uniform. When he applies colour to an engraved plate, or cylinder, or through the interſtices of a perforated pattern, as in the manufacturing of ſome kinds of paper-hangings, he uſes a cylinder entirely covered with hair or briſtles in the manner of a bruſh.

3*dly*, He performs all his impreſſions, even in letter-preſs printing, by the action of a cylinder or cylindrical ſurface. The conſtruction of this machine, and the manner of uſing it, will be intelligible to every reader, who ſhall attentively conſider Plate XL; where fig. 1. repreſents a printing preſs, more eſpecially applicable to the printing of books. A and E are two cylinders, running or turning in a ſtrong frame of wood, or metal, or both. The cylinder A is faced with woollen cloth, and is capable of being preſſed with more or leſs force upon HI, by means of the lever M. HI is a long table, which is capable of moving endwiſe, backwards and forwards, upon the rollers E and K. The roller A acts upon this table by means of a cog-wheel, or by ſtraps, ſo as to draw it backwards and forwards by the motion of its handle L. The table is kept in the ſame line by grooves on its ſides, which contain the cylinder A. D is a chaſe, containing letter ſet up and impoſed. B is a box, containing a colouring-roller, with its diſtributing-rollers CC; it is ſupported by the arm N. O is a cylinder faced with leather, and lying acroſs an ink-block; this cylinder is fixed by the middle to a bended lever moveable on the joint Q.

The action. When D, or the letter, is drawn beneath the cylinder B, it receives ink; and when it has paſſed into the poſition R, a workman places or turns down a tympan with paper upon it (this tympan differs in no reſpect from the uſual one, except that its hinge opens ſidewiſe); it then proceeds to paſs under the cylinder A, which preſſes it ſucceſſively through its whole ſurface. On the other ſide, at S, the workman takes off the paper, and leaves the tympan up. This motion cauſes the cylinder B to revolve continually, and conſequently renders its inked ſurface very uniform, by the action of its diſtributing-rollers CC; and, when the table has paſſed to its extreme diſtance in the direction now ſpoken of, the arm G touches the lever P, and raiſes the cylinder O off the ink-block, by which means it dabs againſt one of the diſtributing rollers, and gives it a ſmall quantity of ink. The returning motion of the table carries the letter again under the roller B, which again inks it, and the proceſs of printing another ſheet goes on as before.

Fig. 2. is another printing-preſs. In this, B is the inking-roller; A is a cylinder, having the letter impoſed upon its ſurface; and E is a cylinder, having its uniform ſurface covered with woollen cloth: theſe three cylinders are connected, either by cogs or ſtraps at the edges of each. The machine is uniformly turned in one direction by the handle L. The workman applies a ſheet of paper to the ſurface of E, where it is retained, either by points in the uſual manner, or by the apparatus to be deſcribed in treating of fig. 4. The paper paſſes between E and A, and receives an impreſſion; after which the workman takes it off, and applies another ſheet; and in the mean time the letter on the ſurface of A paſſes round againſt the ſurface of B, and receives ink during the rotation of B. The diſtributing-rollers CC do their office as in the machine fig. 1.; and once in every revolution the tail F, affixed to B, raiſes the inking-piece G, ſo as to cauſe it to touch one of the diſtributing-rollers, and ſupply it with ink. In this way therefore the repeated printing of ſheet after ſheet goes on.

Fig. 3. is a printing preſs, more particularly adapted to print cottons, ſilks, paper hangings, or other articles which run of a conſiderable length. A is a cylinder covered with woollen cloth, or other ſoft ſubſtance. The web or piece of cotton, or other goods, is paſſed round this cylinder, from the carrying-roller F to the receiving-rollers GH; which are connected by a piece of linen, woollen, or hair-cloth, in the manner of a jack-towel ſewed round them; the rotation of this towel carries away the printed ſtuff or goods, and depoſits them at I. KL is a moveable box, containing three rollers, which move againſt each other in rotation. The loweſt roller C revolves in a maſs of colour, contained in a trough or veſſel in the bottom part of the box KL; the ſurface of this colour is repreſented by the line MN. The next roller B is ſtuffed and covered as deſcribed in ſection 2. The preſſure of B againſt C prevents the cylinder B from receiving too much colour. D is a cut or carved cylinder, which receives colour, during the rotation, from the roller B, and impreſſes it upon the web as it paſſes round the cylinder A; in this way the conſtant and effectual action of the machine is ſufficiently obvious. It muſt be obſerved, that the cylinders ADB and G are connected together by cog-wheels, ſtraps, or other well-known equivalent contrivances; ſo that the handle P drives the whole, without their neceſſarily depending on any adheſion or friction at their ſurfaces. The preſſure of B againſt D is governed by an adjuſtment of the axis of D, whoſe ſockets are capable of a ſmall motion; and the preſſure of D againſt A is governed by the poſition of the whole box KL. When it is required to print more than one colour upon a piece, Mr Nicholſon cauſes it to paſs two or more times through the machine; or, in thoſe caſes where the materials are liable to change their dimenſions, he applies, at one and the ſame time, two or more ſuch boxes as KL, with their reſpective cylinders, ſo that the pattern cylinder of each may make its impreſſion upon the web or material to be printed on.

Fig. 4. is a printing-preſs, chiefly of uſe for books and papers. 1, 2, 3, 4, repreſents a long table, with ledges on each ſide; ſo that the two cylinders A and B can run backwards and forwards without any ſide ſhake. In one of theſe ledges is placed a ſtrip or plate of metal cut into teeth, which lock into correſpondent teeth in each cylinder; by which means the two cylinders roll along, without the poſſibility of changing the relative poſitions of their ſurfaces at any determinate part of the table. This may alſo be effected by ſtraps, and may indeed be accompliſhed, with tolerable accuracy, by the mere rolling of the cylinders on the ſmooth or flat ledges without any proviſion. A is the printing-cylinder, covered with woollen cloth, and B is the inking-cylinder, with its diſtributing rollers. The table may be divided into four compartments, marked with a thicker bounding line than the reſt, and numbered 1, 2, 3, 4. At 1 is placed a ſheet of paper; at 2 is the form or chaſe, containing letter ſet and impoſed; at 3 is an apparatus for receiving the printed ſheet; and 4 is employed in no other uſe than as a place of ſtanding for the carriage E, after it has paſſed through one operation, and when it takes ink at F. Its action is as follows: the carriage is thruſt forward by the workman, and as the roller A paſſes over the ſpace numbered 1, it takes up the ſheet of paper previouſly laid there, while the roller B runs over the form and inks the letter. The ſheet of paper, being wrapped round the cylinder A, is preſſed againſt the form as that cylinder proceeds, and conſequently it receives an impreſſion. When A arrives at the ſpace numbered 3, it lets go the ſheet of paper, while the prominent part of the carriage G ſtrikes the lever P, and raiſes the inking-piece, which applies itſelf againſt one of the diſtributing-rollers. In this manner therefore the cylinder A returns empty, and the cylinder B inked, and in the mean time the workman places another ſheet of paper ready in the ſpace numbered 1. Thus it is that the operation proceeds in the printing of one ſheet after another.

The preceding deſcription is not incumbered with an account of the apparatus by which the paper is taken up and laid down. This may be done in ſeveral ways: Fig. 9. and 10. repreſent one of the methods. DE is a lever, moving on the centre pin C, and having its end D preſſed upwards by the action of the ſpring G. The ſhoulder which contains the pin C is fixed in another piece F, which is inſerted in a groove in the ſurface of the cylinder A (fig. 4.), ſo that it is capable of moving in and out, in a direction parallel to the axis of that cylinder. As that cylinder proceeds, it meets a pin in the table; which (letter P, fig. 9.) acting on the inclined plane at the other end of the lever, throws the whole inwards, in the poſition repreſented in fig. 10.; in which caſe the extremity D ſhoots inwards, and applies itſelf againſt the ſide of the cylinder.

In fig. 11. is a repreſentation of part of the table; the dotted ſquare repreſents a ſheet of paper, and the four ſmall ſhaded ſquares denote holes in the board, with pins ſtanding beſide them. When the lever DE (fig. 10.) ſhoots forward, it is ſituated in one of theſe holes, and advances under the edge of the paper, which conſequently it preſſes and retains againſt the cylinder with its extremity D. Nothing more remains to be ſaid reſpecting the taking up, but that the cylinder is provided with two pair of theſe claſps or levers, which are ſo fixed as to correſpond with the four holes repreſented in fig. 11. It will be eaſy to underſtand how the paper is depoſited in the compartment nº 3. (fig. 4.) A pin P (fig. 10.) riſing out of the platform or table, acts againſt a pin E, projecting ſidewiſe out of the lever, and muſt of courſe draw the ſlider and its lever to the original poſition; the paper conſequently will be let go, and its diſengagement is rendered certain by an apparatus fixed in the compartment numbered 3. (fig. 4.) of exactly the ſame kind as that upon the cylinder, and which, by the action of a pin duly placed in the ſurface of the cylinder A, takes the paper from the cylinder in preciſely the ſame manner as that cylinder originally took it up in the compartment numbered 1 (fig. 4.)

Figs. 5, 6, and 7, repreſent a ſimpler apparatus for accompliſhing the ſame purpoſe. If A *a* B *b* (fig 7.) be ſuppoſed to repreſent a thick plate of metal of a circular form, with two pins, A and B, proceeding ſidewiſe or perpendicularly out of its plane, and diametrically oppoſite to each other, and G another pin proceeding in the direction of that plane, then it is obvious that any force applied to the pin A, ſo as to preſs it into the poſition *a* (by turning the plate on its axis or centre X), will at the ſame time cauſe the pin G to acquire the poſition *g*; and, on the other hand, when B is at *b*, or the dotted repreſentation of the ſide-pin, if any preſſure be applied to reſtore its original poſition at B, the pin *g* will return back to G. Now the figures 5 and 6 exhibit an apparatus of this kind, applied to the cylinder A; and that cylinder, by rolling over the pins P and *p*, properly fixed in the table to re-act upon the apparatus, will cauſe its prominent part G either to apply to the cylinder and claſp the paper, or to riſe up and let it go. The compartment numbered 3 (fig. 4.) muſt of courſe have an apparatus of the ſame kind to be acted upon by pins from A, in order that it may take the paper from that cylinder.

There is one other circumſtance belonging to this machine which remains to be explained. When the carriage E (fig. 4.) goes out in the direction of the numbers 1, 2, 3, 4, both rollers, A and B, preſs the form of letter in their paſſage; but in their return back again the roller A, having no paper upon it, would itſelf become ſoiled, by taking a faint impreſſion from the letter, if it were not prevented from touching it: the manner of effecting this may be underſtood from fig. 12. The apparatus there repreſented is fixed upon the outſide of the carriage E, near the lower corner, in the vicinity of the roller A; the whole of this projects ſidewiſe beyond the ledge of the table, except the ſmall truck or wheel B. The irregularly-triangular piece, which is ſhaded by the ſtroke of the pen, carries this wheel, and alſo a catch moveable on the axis or pin E. The whole piece is moveable on the pin A, which connects it to the carriage. CD, or the part which is ſhaded by dotting, is a detent, which ſerves to hold the piece down in a certain poſition. It may be obſerved, that both the detent and the triangular piece are furniſhed each with a claw, which holds in one direction, but trips or yields in the other, like the jacks of a harpſichord, or reſembling certain pieces uſed in clock and watch making, as is clearly repreſented in the figure. Theſe claws overhang the ſide of the table, and their effect is as follows: There is a pin C (fig. 4.) between the compartments of the table numbered 2 and 3, but which is marked F in fig. 12. where GH repreſents the table. In the outward run of the carriage theſe claws ſtrike that pin, but with no other effect than that they yield for an inſtant, and as inſtantly reſume their original poſition by the action of their reſpective ſlender back-ſprings. When the carriage returns, the claw of the detent indeed ſtrikes the pin, but with as little effect as before, becauſe its derangement is inſtantly removed by the action of the back ſpring of the detent itſelf; but, when the claw of the triangular piece takes the pin, the whole piece is made to revolve on its axis or pin A, the wheel B is forced down, ſo as to lift that end of the carriage, and the detent, catching on the piece at C, prevents the former poſition from being recovered. The conſequence of this is, that the carriage runs upon the truck B (and its correſpondent truck on the oppoſite ſide) inſtead of the cylinder A, which is too much raiſed to take the letter, and ſoil itſelf; but as ſoon as the end of the carriage has paſſed clear of the letter, another pin R (fig. 4.) takes the claw of the detent, and draws it off the triangular piece; at which inſtant the cylinder A ſubſides to its uſual place, and performs its functions as before. This laſt pin R does not affect the claw of the triangular piece, becauſe it is placed too low; and the claw of the detent is made the longeſt, on purpoſe that it may ſtrike this pin.

Fig. 8. repreſents an inſtrument for printing floor-cloths, paper-hangings, and the like, with ſtiff paint and a bruſh. D is a copper or metallic cylinder fixed in a frame A, like a garden roller; its carved part is thin, and is cut through in various places, according to the deſired pattern. A ſtrong axis paſſes through the cylinder, and its extremities are firmly attached to the frame A. To this axis is fixed a veſſel or box of the ſame kind, and anſwering the ſame purpoſe as the box KL in fig. 3. It carries a cylinder P, which revolves in the colour; another cylinder E, which revolves in contact with P; and a third cylinder B, whoſe exterior ſurface is covered with hair, after the manner of a bruſh, and revolves in contact with E. This cylinder B is adjuſted by its axis, in ſuch a manner that its bruſh-part ſweeps in the perforated parts of the metallic cylinder D. The circle C repreſents a cog-wheel, fixed concentric to the cylinder D, and revolving with it; this wheel takes another wheel concentric to, and fixed to, B; hence the action is as follows: When the metallic cylinder is wheeled or rolled along any ſurface, its cog-wheel C drives the bruſh B in the contrary direction; and this bruſh-cylinder, being connected by cogs or otherwiſe with E and P, cauſes thoſe alſo to revolve and ſupply it with colour. As the ſucceſſive openings of the cylinder D, therefore, come in contact with the ground, the ſeveral parts of the bruſh will traverſe the uncovered part of that ground, and paint the pattern upon it. The wheel G, being kept lightly on the ground, ſerves to determine the line of contact, that it ſhall be the part oppoſite to B, and no other.

PRINTS (ſee *Encycl.*) are valuable on many accounts; but they are liable to be ſoiled by ſmoke, vapour, and the excrements of inſects. Different methods have, of courſe, been practiſed to clean them. Some have propoſed ſimple waſhing with clear water, or a ley made of the aſhes of reeds, and then expoſing the prints to the dew. Others have cleaned prints with *aqua fortis* (ſulphuric acid); but both theſe methods are attended with a degree of riſk at leſt equal to their advantages. The following method of cleaning prints is recommended in the ſecond volume of Nicholſon's Journal of Natural Philoſophy, &c. as at once ſafe and efficacious:

"Provide a certain quantity of the common muriatic acid, for example three ounces, in a glaſs bottle, with a ground ſtopper, of ſuch a capacity that it may be only half full. Half an ounce of minium muſt then be added; immediately after which the ſtopper is to be put in, and the bottle ſet in a cold and dark place. The heat, which ſoon becomes perceptible, ſhews the beginning of the new combination. The minium abandons the greateſt part of its oxygen with which the fluid remains impregnated, at the ſame time that it acquires a fine golden yellow, and emits the deteſtable ſmell of oxygenated muriatic acid. It contains a ſmall portion of muriat of lead; but this is not at all noxious in the ſubſequent proceſs. It is alſo neceſſary to be obſerved, that the bottle muſt be ſtrong, and the ſtopper not too firmly fixed, otherwiſe the active elaſtic vapour might burſt it. The method of uſing this prepared acid is as follows:

"Provide a ſufficiently large plate of glaſs, upon which one or more prints may be ſeparately ſpread out. Near the edges let there be raiſed a border of ſoft white wax half an inch high, adhering well to the glaſs and flat at top. In this kind of trough the print is to be placed in a bath of freſh urine, or water containing a ſmall quantity of ox-gall, and kept in this ſituation for three or four hours. The fluid is then to be decanted off, and pure warm water poured on, which muſt be changed every three or four hours until it paſſes limpid and clear. The impurities are ſometimes of a reſinous nature, and reſiſt the action of pure water. When this is the caſe, the waſhed print muſt be left to dry, and alcohol is then to be poured on and left for a time. After the print is thus cleaned, and all the moiſture drained off, the muriatic acid prepared with minium is to be poured on in ſufficient quantity to cover the print; immediately after which another plate of glaſs is to be laid in contact with the rim of wax, in order to prevent the inconvenient exhalation of the oxygenated acid. In this ſituation the yelloweſt print will be ſeen to recover its original whiteneſs in a very ſhort time. One or two hours are ſufficient to produce the deſired effect; but the print will receive no injury if it be left in the acid for a whole night. Nothing more is neceſſary to complete the work, than to decant off the remaining acid, and waſh away every trace of acidity by repeated affuſions of pure water. The print being then left to dry (in the ſun if poſſible) will be found white, clear, firm, and in no reſpect damaged either in the texture of the paper or the tone and appearance of the impreſſion."

The judicious editor of the Journal ſubjoins the following note, to which collectors of prints will do well to pay attention: "As I have not repeated this proceſs, I cannot eſtimate how far the preſence of the lead may weaken the corroſive action of the acid on the paper; but I ſhould be diſpoſed to recommend a previous dilution of the acid with water. Whoever uſes this proceſs will of courſe make himſelf maſter of the proportion of water required to dilute the acid, by making his firſt trials with an old print of no value."

PRISM, in geometry, is a body or a ſolid, whoſe two ends are any plane figures which are parallel, equal, and ſimilar; and its ſides, connecting thoſe ends, are parallelograms. The definition of this figure in the *Encyclopædia* we muſt, in candour, acknowledge to be unaccountably indiſtinct, if not unintelligible.

PRISMOID, is a ſolid or body, ſomewhat reſembling a priſm, but that its ends are any diſſimilar parallel plane figures of the ſame number of ſides; the upright ſides being trapezoids.—If the ends of the priſmoid be bounded by diſſimilar curves, it is ſometimes called a *cylindroid*.

PRISON is ſaid, in the *Encyclopædia*, to be only a place of ſafe cuſtody, not a place of puniſhment. Such

POSITION PLATE XL.

Fig. 1.

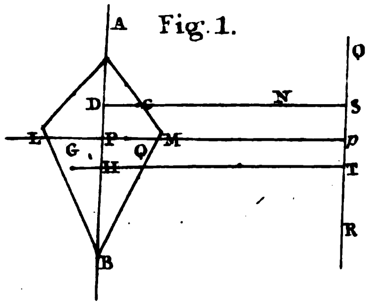


Fig. 2.

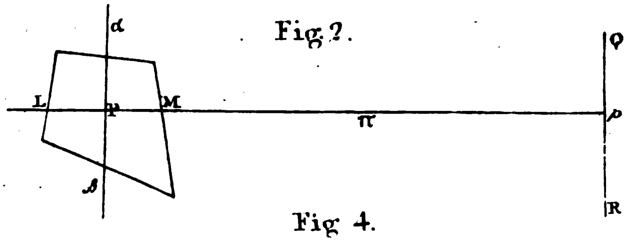


Fig. 3.

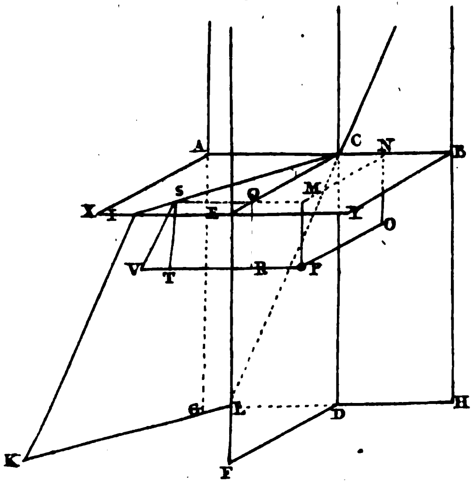
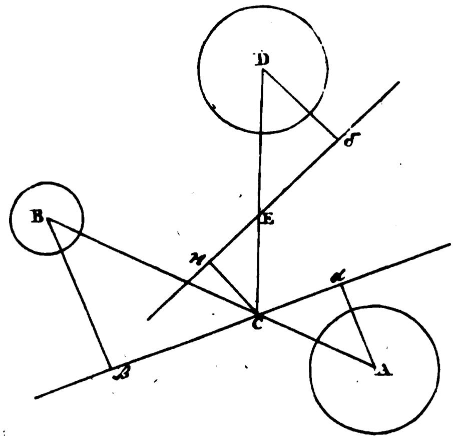
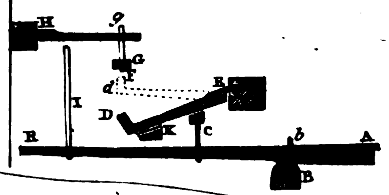


Fig. 4.



KEY &c. of MASON'S PIANO FORTE



PRINTING PRESS

Fig. 1.

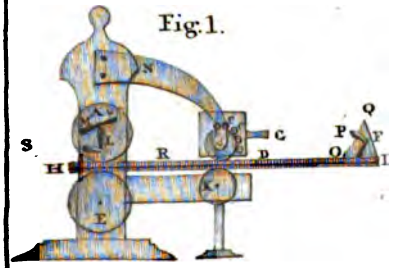


Fig. 2.

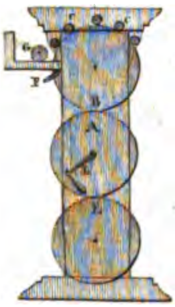


Fig. 3.

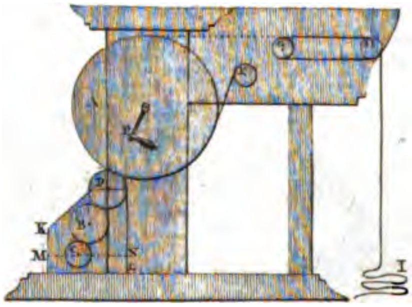


Fig. 9.

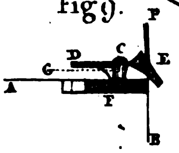


Fig. 5.

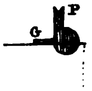


Fig. 10.

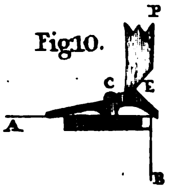


Fig. 6.

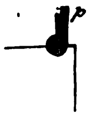


Fig. 8.

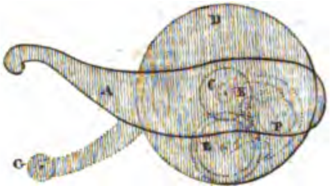


Fig. 4.

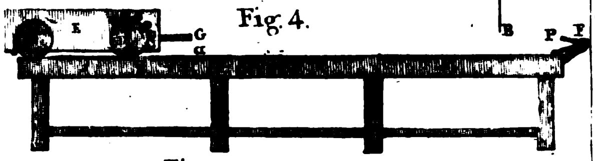


Fig. 7.

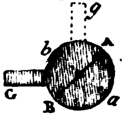


Fig. 11.

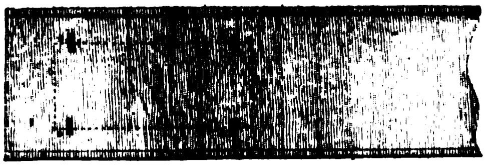
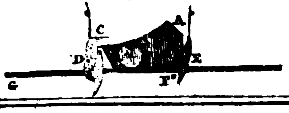


Fig. 12.



B. Graves sculp.

PHOTOMETER PLATE XLI.

OPERA GLASS.

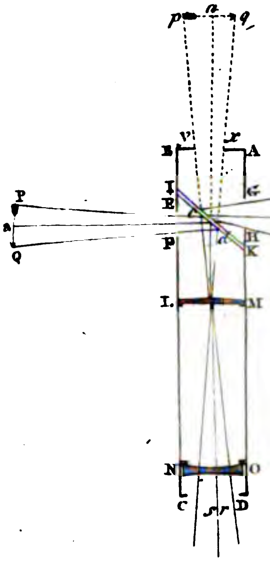


Fig. 1.

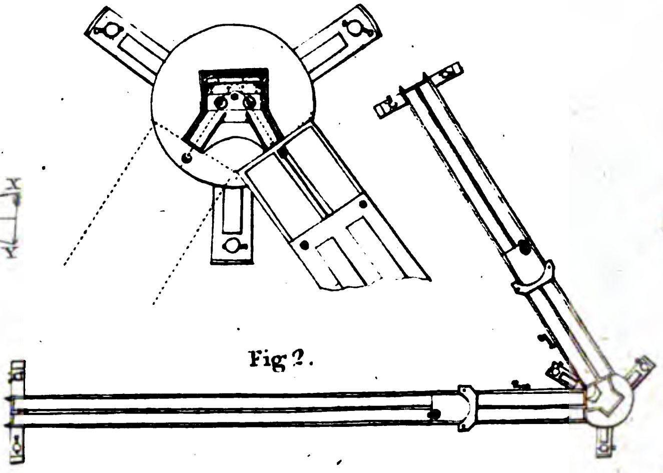
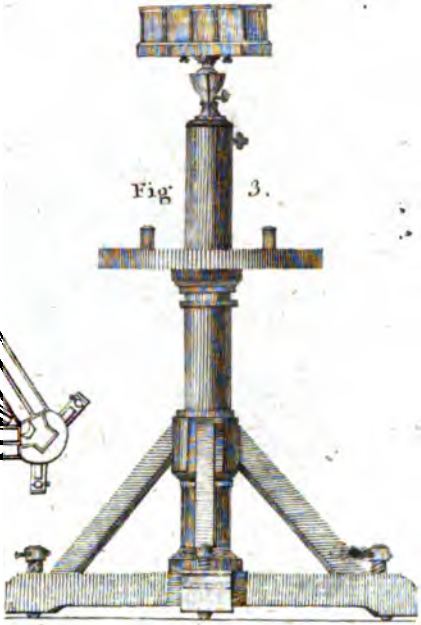


Fig. 2.



PENNATULA

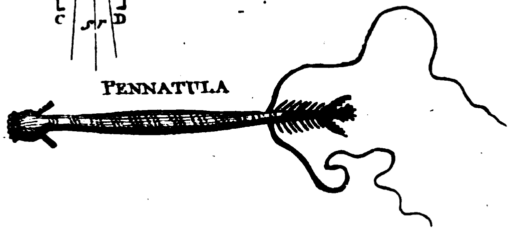
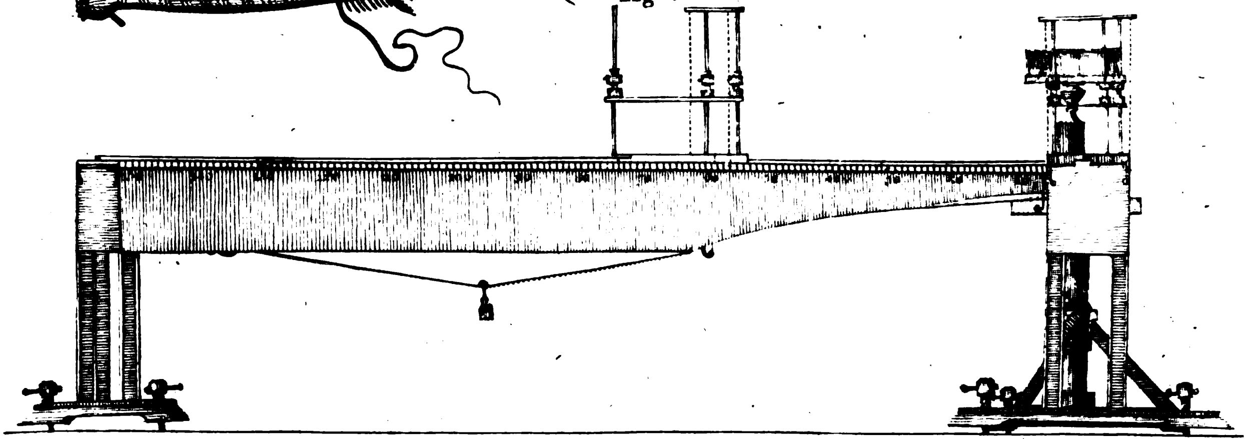


Fig. 4.



BLEACHING

Fig. 1.

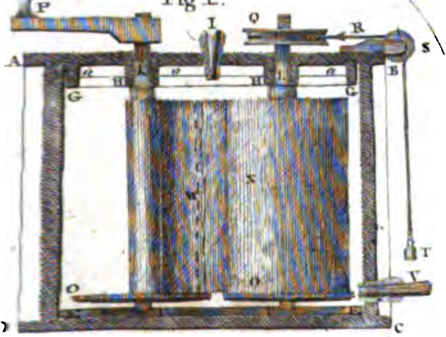
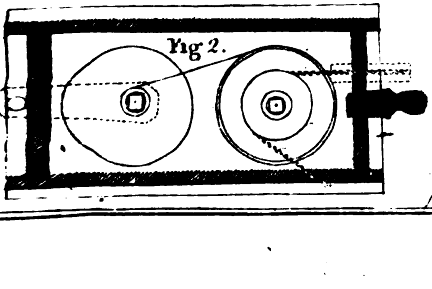


Fig. 2.



PERCUSSION

Fig. 1.

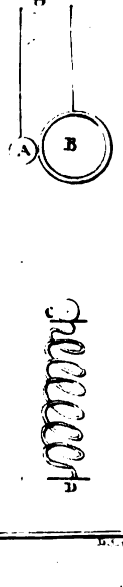
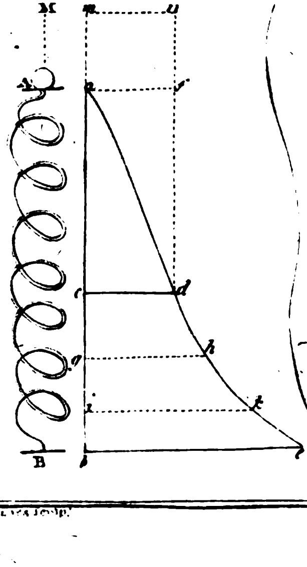
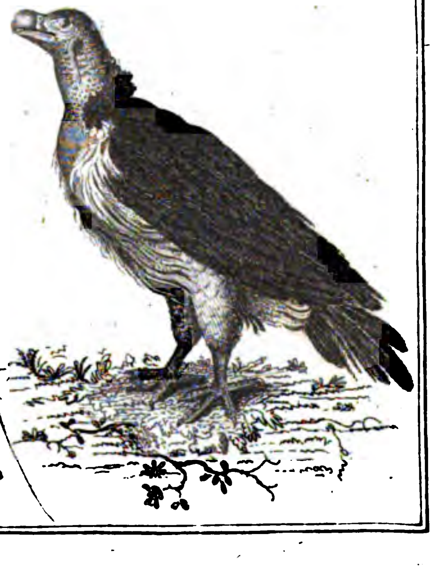


Fig. 2.



ORICOU



D. Lizars sculp.

was, no doubt, the original intention of Engliſh priſons; but now temporary confinement is, in England as well as elſewhere, inflicted as a puniſhment for certain crimes. Perhaps it would be expedient to ſubſtitute this puniſhment more frequently than is yet done in Great Britain, for tranſportation and death; proportioning the length of the confinement, as well as its cloſeneſs, to the heinouſneſs of the crime. In no country, we believe, is this more accurately done, or to better purpoſe, than in Pennſylvania; and ſurely in no country has impriſonment been more abuſed than in Venice under the old government.

By the laws of Pennſylvania, puniſhment by impriſonment is impoſed, not only as an expiation of paſt offences, and an example to the guilty part of ſociety, but alſo for another important purpoſe—the reformation of the criminal's morals. The regulations of the gaol are calculated to promote this effect as ſoon as poſſible; ſo that the building deſerves the name of a *penitentiary houſe* more than that of a *gaol* (ſee PHILADELPHIA, *Encycl.*) As ſoon as a criminal is committed to the priſon, he is made to waſh; his hair is ſhorn; and, if not decently clothed, he is furniſhed with clean apparel. He is then thrown into a ſolitary cell, about nine feet long and four wide, where he remains debarred from the ſight of every living being except his gaoler, whoſe duty is to attend to his bare neceſſities, but who is forbidden on any account to hold converſation with him. If a priſoner be at all refractory, or if the offence for which he is committed be of a very atrocious nature, he is then confined to a cell ſecluded even from the light of heaven. The treatment of each priſoner, during his confinement, is varied according to his crime and his ſubſequent repentance. Solitary confinement in a dark cell is looked upon as the ſevereſt uſage; next, ſolitary confinement in a cell with the admiſſion of light; next, ſolitary confinement in a cell, where the priſoner is allowed to do ſome ſort of work; and, laſtly, labour in company with others. The longeſt period of confinement is for a rape, which is not to be leſs than ten years, nor more than twenty-one; for high treaſon, it is not to exceed twelve, nor fall ſhort of ſix years.

The priſoners are obliged to bathe twice every week, proper conveniences for that purpoſe being provided within the walls of the priſon, and alſo to change their linen, with which they are regularly ſupplied. Thoſe in ſolitary confinement are kept upon bread and water; but thoſe who labour are allowed broth, porridge, puddings, and the like. Meat is diſpenſed only in ſmall quantities, twice in the week; and on no pretence whatever is any other beverage than water ſuffered to be brought into the priſon. Thoſe who labour are employed in the trade to which they have been accuſtomed; and for thoſe acquainted with no particular trade, ſome kind of work is deviſed which they can perform. One room is ſet apart for ſhoemakers, another for tailors, a third for carpenters, and ſo on. In the yards are ſtone cutters, ſmiths, nailers, &c. In a word, this priſon has all the advantages of the raſping houſe of Amſterdam, without any of its enormous defects. See *CORRECTION-Houſe* in this *Suppl.*

The priſon of Venice is of a very different deſcription, and is worthy of notice here only as a curioſity in the annals of tyranny, which has, we hope, paſſed away with the government which contrived it. Dr Moſeley, in conſequence of his being an Engliſh phyſician (a character then highly reſpected in Venice), was permitted, on the 16th of September 1787, to viſit the common priſon, but was abſolutely refuſed admittance into the *Sotto Piombi*, where the ſtate priſoners were kept. As the Doctor believes that no foreigner beſides himſelf ever witneſſed the ſcenes, even in the common priſon, which he relates, we ſhall give his relation in his own words.

"I was conducted (ſays he) through the priſon by one of its inferior dependants. We had a torch with us. We crept along narrow paſſages as dark as pitch. In ſome of them two people could ſcarcely paſs each other. The cells are made of maſſy marble; the architecture of the celebrated Sanſovini.

"The cells are not only dark, and black as ink, but being ſurrounded and confined with huge walls, the ſmalleſt breath of air can ſcarcely find circulation in them. They are about nine feet ſquare on the floor, arched at the top, and between ſix and ſeven feet high in the higheſt part. There is to each cell a round hole of eight inches diameter, through which the priſoner's daily allowance of twelve ounces of bread and a pot of water is delivered. There is a ſmall iron door to the cell. The furniture of the cell is a little ſtraw and a ſmall tub; nothing elſe. The ſtraw is renewed and the tub emptied through the iron door occaſionally.

"The diet is ingeniouſly contrived for the perduration of puniſhment. Animal food, or a cordial nutritious regimen, in ſuch a ſituation, would bring on diſeaſe, and defeat the end of this Venetian juſtice. Neither can the ſoul, if ſo inclined, ſteal away, wrapt up in ſlumbering deluſion, or ſink to reſt; from the admonition of her ſad exiſtence, by the gaoler's daily return.

"I ſaw one man who had been in a cell thirty years; two who had been twelve years; and ſeveral who had been eight and nine years in their reſpective cells.

"By my taper's light I could diſcover the priſoners horrid countenances. They were all naked. The man who had been there thirty years, in face and body was covered with long hair. He had loſt the arrangement of words and order of language. When I ſpoke to him, he made an unintelligible noiſe, and expreſſed fear and ſurpriſe; and, like ſome wild animals in deſarts, which have ſuffered by the treachery of the human race, or have an inſtinctive abhorrence of it, he would have fled like lightning from me if he could.

"One whoſe faculties were not ſo obliterated; who ſtill recollected the difference between day and night; whoſe eyes and ears, though long cloſed with a ſilent blank, ſtill languiſhed to perform their natural functions—implored, in the moſt piercing manner, that I would prevail on the gaoler to murder him, or to give him ſome inſtrument to deſtroy himſelf. I told him I had no power to ſerve him in this requeſt. He then entreated I would uſe my endeavours with the inquiſitors to get him hanged, or drowned in the Canal' Orfano. But even in this I could not ſerve him: death was a favour I had not intereſt enough to procure for him.

"This kindneſs of death, however, was, during my ſtay in Venice, granted to one man, who had been ‘ from the cheerful ways of man cut off’ thirteen years.

“ Before he left his dungeon I had ſome converſation with him; this was ſix days previous to his execution. His tranſport at the proſpect of death was ſurpriſing. He longed for the happy moment No ſaint ever exhibited more fervour in anticipating the joys of a future ſtate, than this man did at the thoughts of being releaſed from life, during the four days mockery of his trial.

“ It is in the Canal’ Orfano where veſſels from Turkey and the Levant perform quarantine. This place is the watery grave of many who have committed political or perſonal offences againſt the ſtate or ſenate, and of many who have committed no offences at all. They are carried out of the city in the middle of the night, tied up in a ſack with a large ſtone faſtened to it, and thrown into the water. Fiſhermen are prohibited, on forfeiture of their lives, againſt fiſhing in this diſtrict. The pretence is the plague. This is the ſecret hiſtory of people being loſt in Venice.

“ The government, with age, grew feeble; was afraid of the diſcuſſion of legal proceſs and of public executions; and navigated this rotten Bucentaur of the Adriatic by ſpies, priſons, aſſaſſination, and the Canal’ Orfano.”

This is indeed a frightful narrative, and, we doubt not, true as well as frightful; but when, from the ſtate of the Venetian priſons, the author inſinuates, that Howard was not actuated by genuine benevolence, and infers, or wiſhes his reader to infer, that the propoſal of that celebrated philanthropiſt for ſubſtituting ſolitary confinement, in many caſes, for capital puniſhment, muſt have reſulted from his not taking into conſideration the *mind* of the criminal—the inſinuation, to ſay the leaſt of it, is ungenerous, and the concluſion is at war with the premiſes. That there was ſomething romantic and ſuperfluous in Howard's wanderings, we readily admit; but it ſeems impoſſible to doubt of the reality of his benevolence; and though the horrid priſon of Venice, into which, as the Doctor aſſures us, Mr Howard never entered, was calculated to injure the body without improving the mind of the criminal, it does not follow but that ſolitary confinement, under ſuch regulations as at Philadelphia, is the beſt means that have yet been thought of for obtaining the object neareſt Howard's heart, the reformation of the morals of the criminal.

PROCYON, in aſtronomy, a fixed ſtar of the ſecond magnitude, in Canis Minor, or the Little Dog.

PROSTHAPHERESIS, in aſtronomy, the difference between the true and mean motion, or between the true and mean place, of a planet, or between the true and equated anomaly; called alſo *equation of the orbit*, or *equation of the centre*, or ſimply the *equation*; and it is equal to the angle formed at the planet, and ſubtended by the eccentricity of its orbit.

PROTRACTING, or PROTRACTION, in ſurveying, the act of plotting or laying down the dimenſions taken in the field, by means of a protractor, &c. Protracting makes one part of ſurveying.

PROTRACTING-Pin, a fine pointed pin or needle, fitted into a handle, uſed to prick off degrees and minutes from the limb of the protractor.

PRUNING. Under this title (*Encycl.*) it is obſerved, that when large branches of trees bearing ſtone-fruit are taken off, the trees are ſubject to gum and decay. For this a remedy has been invented by *Thomas Skip Dyot Bucknall*, Eſq; of Conduit-ſtreet, which, notwithſtanding many objections made to it at firſt, experience has proved to be ſucceſsful, and for the diſcovery of which the Society for the Encouragement of Arts, &c. voted the ſilver medal to the diſcoverer. It is as follows:

Cut every branch which ſhould be taken away cloſe to the place of its ſeparation from the trunk; ſmooth it well with a knife; and then with a painter's bruſh ſmear the wound over with what Mr Bucknall calls *medicated tar*. This medicated tar is compoſed of one quarter of an ounce of corroſive ſublimate, reduced to fine powder by beating with a wooden hammer, and then put into a three-pint earthen pipkin, with about a glaſs full of gin or other ſpirit, ſtirred well together, and the ſublimate thus diſſolved. The pipkin is then filled by degrees with vegetable or common tar, and conſtantly ſtirred, till the mixture be blended together as intimately as poſſible; and this quantity will at any time be ſufficient for two hundred trees. To prevent danger let the corroſive ſublimate be mixed with the tar as quickly as poſſible after it is purchaſed; for, being of a very poiſonous nature to all animals, it ſhould not be ſuffered to lie about a houſe, for fear of miſchief to ſome part of the family.

By the application of this compoſition, Mr Bucknall can, without the ſmalleſt danger, uſe the pruning hook on all kinds of trees much more freely than we have recommended its uſe in the article referred to. “ I give no attention (ſays he) to fruit-branches, and wood-branches; but beg, once for all, that no branch ſhall ever be ſhortened, unleſs for the figure of the tree, and then conſtantly taken off cloſe to the ſeparation, by which means the wound ſoon heals. The more the range of the branches ſhoots circularly, a little inclining upwards, the more equally will the ſap be diſtributed, and the better will the tree bear; for, from that circumſtance, the ſap is more evenly impelled to every part. Do not let the ranges of branches be too near each other; for remember all the fruit and the leaves ſhould have their full ſhare of the ſun; and where it ſuits let the middle of the tree be free from wood, ſo that no branch ſhall ever croſs another, but all the extreme ends point outwards.”

PULO, the name of ſeveral iſlands of Aſia, in the Indian Ocean; the principal of which alone, according to Dr Brooke's, is inhabited. This is the iſland

Pulo-Condore, which, being viſited by Lord Macartney as he ſailed to China, is thus deſcribed by Sir George Staunton. “ It has the advantage of convenient anchoring places in either monſoon. The ſquadron accordingly ſtopped on the 17th of May, in a ſpacious bay on the eaſtern ſide of the iſland; and came to anchor at the entrance of its ſouthern extremity, as the water ſhoaled there to five fathoms and a half, occaſioned by a bank which ſtretches acroſs two-thirds of the entrance. It was found afterwards, that beyond the bank there is a ſafe paſſage to the inner part of the bay, the north of which is ſheltered by a ſmall iſland lying to the eaſtward. The whole of the bay is formed by four ſmall iſlands, which approach ſo nearly to each other, as to appear, from ſeveral points, to join.

They all ſeem to be the rude fragments of primitive mountains, ſeparated from the great continent in the lapſe of time. The principal iſland is eleven or twelve miles in length, and about three in breadth. It is in the form of a creſcent, and conſiſts of a ridge of peaked hills. Its latitude, as calculated from a meridional obſervation, is 8° 40′ north from the equator; and its longitude, according to a good chronometer, is 105° 55′ eaſt from Greenwich.

"The Engliſh had a ſettlement on Condore until the beginning of the preſent century, when ſome Malay ſoldiers in their pay, in reſentment for ſome unjuſtifiable treatment, murdered their ſuperiors, with the exception of a very few who eſcaped off the iſland, where no Europeans have ſince reſided. At the bottom of the bay was a village ſituated cloſe to a fine ſandy beach, with a long range of cocoa-nut trees before it, and it was defended from the north-eaſt ſea by a reef of coral rocks, within which was good anchorage for ſmall veſſels, and an eaſy landing for boats. A party went on ſhore from Lord Macartney's ſquadron, with the precaution, however, of being armed, as large canoes were eſpied within the reef, which might have been Malay pirates. Several of the inhabitants came to the beach, and with the appearance of much urbanity of manners welcomed them on ſhore, and conducted them to the houſe of their chief. It was a neat bamboo cabin, larger than the reſt. The floor was elevated a few feet above the ground, and ſtrewed with mats, on which were aſſembled as many men as the place could hold. It was apparently on the occaſion of ſome feſtival, or pleaſurable meeting. There was in one of the apartments an altar decorated with images, and the partitions hung with figures of monſtrous deities; but the countenances and deportment of the people conveyed no idea of religious awe, and no perſon was ſeen in the poſture of prayer or adoration. A few ſpears ſtood againſt the wall with their points downwards, together with ſome matchlocks and a ſwivel gun. The dreſs of thoſe people was compoſed chiefly of blue cotton worn looſely about them; and their flat faces and little eyes denoted a Chineſe origin or relation. Several long ſlips of paper, hanging from the ceiling, were covered with columns of Chineſe writing. One of the miſſionaries, who was of the party, could not, however, in any degree, underſtand their converſation; but when the words were written, they inſtantly became intelligible to him. Though their colloquial language was altogether different from what is ſpoken in China, yet the characters were all Chineſe; and the fact was clearly aſcertained on this occaſion, that thoſe characters have an equal advantage with Arabic numbers, of which the figures convey the ſame meaning wherever known; whereas the letters of other languages denote not things, but elementary ſounds, which combined variouſly together, form words, or more complicated ſounds, conveying different ideas in different languages, though the form of their alphabet be the ſame.

"The inhabitants of Pulo Condore were, it ſeems, Cochin-Chineſe, with their deſcendants, who fled from their own country, in conſequence of their attachment to one of its ſovereigns, dethroned by ſeveral of his own ſubjects. It was propoſed to purchaſe proviſions here; and the people promiſed to have the ſpecified quantity ready, if poſſible, the next day, when it was intended, if the weather ſhould be favourable, to land the invalids. The next morning was fair in the beginning; and a party of pleaſure was made from the Hindoſtan to a ſmall iſland cloſe to Pulo Condore. They were ſcarcely arrived upon it when the weather began to lower; and the boat ſet off on its return, in order to reach the ſhip before the impending ſtorm ſhould begin.

"With difficulty it reached the ſhip; and as ſoon as the weather became fair, meſſengers were diſpatched on ſhore to receive and pay for the proviſions promiſed. When they arrived at the village, they were aſtoniſhed to find it abandoned. The houſes were left open, and none of the effects, except ſome arms, that had on the firſt viſit been perceived within them, or even of the poultry feeding about the doors, were taken away. In the principal cabin a paper was found, in the Chineſe language, of which the literal tranſlation purported, as nearly as it could be made, that 'the people of the iſland were few in number, and very poor, yet honeſt, and incapable of doing miſchief; but felt much terror at the arrival of ſuch great ſhips and powerful perſons, eſpecially as not being able to ſatisfy their wants in regard to the quantity of cattle and other proviſions, of which the poor inhabitants of Pulo Condore had ſcarcely any to ſupply, and conſequently could not give the expected ſatisfaction. They therefore, through dread and apprehenſion, reſolved to fly to preſerve their lives. That they ſupplicate the great people to have pity on them; that they left all they had behind them, and only requeſted that their cabins might not be burnt; and conclude by proſtrating themſelves to the great people a hundred times.'

"The writers of this letter had probably received ill treatment from other ſtrangers. It was determined that they ſhould not continue to think ill of all who came to viſit them. On their return they were perhaps as much ſurpriſed to find their houſes ſtill entire, as their viſitors had been who found they were deſerted. Nothing was diſturbed; and a ſmall preſent, likely to be acceptable to the chief, was left for him in the principal dwelling, with a Chineſe letter, ſignifying that 'the ſhips and people were Engliſh, who called merely for refreſhment, and on fair terms of purchaſe, without any ill intention; being a civilized nation, endowed with principles of humanity, which did not allow them to plunder or injure others who happened to be weaker or fewer than themſelves."

Pulo Lingen, another of this cluſter, is likewiſe a conſiderable iſland, remarkable for a mountain in its centre, terminating in a fork like Parnaſſus; but to which the unpoetical ſeamen beſtow the name of *aſſes ears*. Every day preſented new iſlands to the view, diſplaying a vaſt variety in form, ſize, and colour. Some iſolated, and ſome collected in cluſters. Many were clothed with verdure; ſome had tall trees growing on them; others were mere rocks, the reſort of innumerable birds, and whitened with their dung.

PUNCTUATION, in grammar, is an art with which we have ſaid, in the *Encyclopædia*, that the ancients were entirely unacquainted. Candour obliges us to confeſs that this was ſaid raſhly. A learned writer, in the Monthly Magazine for September 1798, who ſubſcribes J. Warburton, has proved, we think completely, that the art is not wholly modern; and we ſhall lay his proofs, in his own words, before our readers.

" Some ſpecies of pauſes and diviſions of ſentences in ſpeaking and writing muſt have been coeval with the knowledge of communicating ideas by ſound or by ſymbols. Suidas * ſays, that the *period* and the *colon* were diſcovered and explained by Thraſymacus, about 380 years before the Chriſtian æra. Cicero † ſays, that Thraſymacus was the firſt who ſtudied oratorical numbers, which entirely conſiſted in the artificial ſtructure of periods and colons. It appears from a paſſage in Ariſtotle ‡, that punctuation was known in his time. The learned Dr Edward Bernard § refers the knowledge of pointing to the time of that philoſopher, and ſays, that it conſiſted in the different poſitions of one ſingle point. At the bottom of a letter, thus, (A.) it was equivalent to a comma; in the middle (A·) it was equal to a colon; at the top (A˙) it denoted a period, or the concluſion of a ſentence.

" This mode was eaſily practiſed in Greek manuſcripts, while they were written in capitals. But when the ſmall letters were adopted, that is, about the 9th century, this diſtinction could not be obſerved; a change was therefore made in the ſcheme of punctuation. *Unciales literas hodierno uſu dicimus eas in vetuſtis codicibus, quæ priſcam formam ſervant, ac ſolutæ ſunt, nec mutuò colligantur. Hujus modi literæ unciales obſervantur in libris omnibus ad nonum uſque ſeculum*—Montf. Palæog. Recens. p. xii.

" According to Cicero, the ancient Romans, as well as the Greeks, made uſe of points. He mentions them under the appellation of *librariorum notæ;* and in ſeveral parts of his works he ſpeaks of '*interpunctæ clauſulæ in orationibus*,' of '*clauſulæ atque interpuncta verborum*,' of '*interpunctiones verborum*,' &c *.

" Seneca, who died A. D. 65, expreſsly ſays, that Latin writers, in his time, had been uſed to punctuation. '*Nos* †, *cum ſcribimus interpungere conſuevimus*.' Muretus and Lipſius imagined that theſe words alluded to the inſertion of a point after each word: but they certainly were miſtaken; for they muſt neceſſarily refer to marks of punctuation in the diviſion of ſentences, becauſe in the paſſage in which theſe words occur, Seneca is ſpeaking of one Q. Haterius, who made no pauſes in his orations.

" According to Suetonius, in his *Illuſt. Gram.* Valerius Probus procured copies of many old books, and employed himſelf in correcting, pointing, and illuſtrating them; devoting his time to this and no other part of grammar. *Multa exemplaria contracta emendare, ac diſtinguere et adnotare curavit; ſoli huic, nec ulli præterea, grammatices parti deditus.*

" It appears from hence, that in the time of Probus, or about the year 68, Latin manuſcripts had not been uſually pointed, and that grammarians made it their buſineſs to ſupply this deficiency.

" Quintilian, who wrote his celebrated treatiſe on Oratory, about the year 88, ſpeaks of commas, colons, and periods; but it muſt be obſerved, that by theſe terms he means clauſes, members, and complete ſentences, and not the marks of punctuation ‡.

" Ælius Donatus § publiſhed a treatiſe on Grammar in the 4th century, in which he explains the *diſtinctio*, the *media diſtinctio*, and the *ſubdiſtinctio;* that is, the uſe of a ſingle point in the various poſitions already mentioned.

" Jerom *, who had been the pupil of Donatus, in his Latin Verſion of the Scriptures, made uſe of certain diſtinctions or diviſions, which he calls *cola* and *commata*. It has, however, been thought probable, that theſe diviſions were not made by the addition of any points or ſtops; but were formed by writing, in one line, as many words as conſtituted a clauſe, equivalent to what we diſtinguiſh by a comma or a colon. Theſe diviſions were called στιχοι or ρηματα; and had the appearance of ſhort irregular verſes in poetry. There are ſome Greek manuſcripts ſtill extant, which are written in this manner †."

Mr Warburton ſays, that the beſt treatiſe upon punctuation that he has ſeen, was publiſhed ſome years ſince by an anonymous author, and dedicated to Sir Clifton Wintringham, Bart. With that treatiſe we are not acquainted; but we do not think that the art of punctuation can be taught by rules. The only way to acquire it is to obſerve attentively how the moſt perſpicuous writers diſpoſe of their periods, colons, ſemicolons, and commas. This will make us acquainted with the importance of each; and then every writer, who knows his own meaning, muſt be capable of pointing his own pages more correctly than any other man.

PYRAMIDOID, is ſometimes uſed for the parabolic ſpindle, or the ſolid formed by the rotation of a ſemiparabola about its baſe or greateſt ordinate. See PARABOLIC *Spindle*.

PYRITES. See MINERALOGY in this *Suppl.*—In the third volume of Mr Nicholſon's Philoſophical Journal, we have a method of making artificial pyrites, which we ſhall give in the words of the author.

" I impregnated water (ſays he) very ſtrongly with carbonic acid, and introducing ſome iron filings, I continued the impregnation for a day or two, and afterwards allowed the water to ſtand in a well corked bottle for ſome days, till the acid had taken up as much iron as poſſible. I then poured it into an aerating apparatus; threw up the hepatic gas from ſulphuret of potaſh and ſulphuric acid; and after having agitated the water till it had got a good doſe of the gas, I poured the water into a large baſon: this was in the evening, and next morning when I looked at it I found it covered with a pretty thick film of a moſt beautiful variegated pyrites. I had ſo little of it, that the only proof I had of its being this ſubſtance was, that it was ignited on its being placed on a hot poker."

QUADRATURE,

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* Qui primus periodum et colon monſtravit. *Suidas de Thraſymacho.*

† *Cicero Orat.* § 33.

‡ *Rhet.* Lib. iii. c. 5.

§ *Bern Orbis erud. Literat.* tab. 30. edit. 1689.

* *Cic. de Orat.* l. iii. § 26. ibid. 7. *Orat. pro Murena*, § 25.

† *Sen. Epiſt.* 40.

‡ [illegible]

§ [illegible]

* [illegible]

† [illegible] *Montf.* [illegible] *Græc.* lib. iii. [illegible]

Q.

QUADRATURE, in geometry (ſee that article, and likewiſe FLUXIONS, *Encycl.*), has employed the time and ingenuity of ſome of the moſt eminent mathematicians both of ancient and of modern times. Dr Halley's method of computing the ratio of the diameter of the circle to its circumference, was conſidered by himſelf, and other learned mathematicians, as the eaſieſt the problem admits of. And although, in the courſe of a century, much eaſier methods have been diſcovered, ſtill a celebrated mathematician of our own times has expreſſed an opinion, that no other aliquot part of the circumference of a circle can be ſo eaſily computed by means of its tangent as that which was choſen by Dr Halley, viz. the arch of 30 degrees. Without taking upon him to determine whether this opinion be juſt or not, the Rev. John Hellins has ſhewn how the ſeries by which Dr Halley computed the ratio of the diameter to the circumference of the circle may be transformed into others of ſwifter convergency, and which, on account of the ſucceſſive powers of $\frac{1}{80}$ which occur in them, admit of an eaſy ſummation. We ſhall give the memoir in the author's own words.

"1. The propoſed transformation is obtained by means of different forms in which the fluents of ſome fluxions may be expreſſed; and to proceed with greater clearneſs, "I will here (ſays Mr Hellins) ſet down the fluxion in a general form, and its fluent, in the two ſeries which are uſed in the following particular inſtance, and may be applied with advantage in ſimilar caſes.

"2. The fluent of $\frac{x^{m-1}\dot{x}}{1-x^n}$ is $= \frac{x^m}{m} + \frac{x^{m+n}}{m+n} + \frac{x^{m+2n}}{m+2n} + \frac{x^{m+3n}}{m+3n}$, &c. which ſeries, being of the ſimpleſt form which the fluent ſeems to admit, was firſt diſcovered, and probably is the moſt generally uſeful. But it has alſo been found, that the fluent of the ſame fluxion may be expreſſed in ſeries of other forms, which, though leſs ſimple than that above written, yet have their particular advantages. Amongſt thoſe other forms of ſeries which the fluent admits of, that which ſuits my preſent purpoſe is

$$\frac{x^m}{m.\overline{1-x^n}} - \frac{nx^{m+n}}{m.\overline{m+n}.\overline{1-x^n}|^2} + \frac{n.2n.x^{m+2n}}{m.\overline{m+n}.\overline{m+2n}.\overline{1-x^n}|^3} - \frac{n.2n.3n.x^{m+3n}}{m.\overline{m+n}.\overline{m+2n}.\overline{m+3n}.\overline{1-x^n}|^4}$$

+ &c. which, to ſay nothing of other methods, may eaſily be inveſtigated by the rule given in p. 64. of the third edition of *Emerſon's Fluxions*; or its equality with the former ſeries may be proved by algebra.

"3. On account of the ſign — before x^n, in the laſt ſeries, it may be proper to remark, that its convergency, by a geometrical progreſſion, will not ceaſe till $\frac{x^n}{1-x^n}$ becomes $= 1$, or x becomes $= \sqrt[n]{\frac{1}{2}}$; and that when x is a ſmall quantity, and n a large number, this ſeries will converge almoſt as ſwiftly as the former. For inſtance, if x be $= \sqrt{\frac{1}{3}}$, and $n = 8$, which are the values in the following caſe, the former ſeries will converge by the quantity $x^n = \sqrt{\frac{1}{3}}|^8 = \frac{1}{81}$, and this ſeries by the quantity $\frac{x^n}{1-x^n} = \frac{\frac{1}{81}}{1-\frac{1}{81}} = \frac{1}{80}$; where the difference in convergency will be but little, and the diviſions by 80 eaſier than thoſe by 81.

"4. With reſpect to the indices m and n, as they are here ſuppoſed to be affirmative whole numbers, and will be ſo in the uſe I am about to make of them, the reader need not be detained with any obſervations on the caſes in which theſe fluents will fail, when the indices have contrary ſigns.

"5. It may be proper further to remark, that by putting $\frac{x^n}{1-x^n} = z$, and calling the firſt, ſecond, third, &c. terms of the ſeries $\frac{x^m}{m.\overline{1-x^n}} - \frac{nx^{m+n}}{m.\overline{m+n}.\overline{1-x^n}|^2} + \frac{n.2nx^{m+2n}}{m.\overline{m+n}.\overline{m+2n}.\overline{1-x^n}|^3}$ + &c. A, B, C, &c. reſpectively, the ſeries will be expreſſed in the conciſe and elegant notation of Sir Iſaac Newton, viz. $\frac{x^m}{m.\overline{1-x^n}} - \frac{nzA}{m+n} + \frac{2nzB}{m+2n} - \frac{3nzC}{m+3n}$ + &c. which is well adapted to arithmetical calculation.

"6. I come now to the transformation propoſed, which will appear very eaſy, as ſoon as the common ſeries, expreſſing the length of an arch in terms of its tangent, is properly arranged.

"If the radius of a circle be 1, and the tangent of an arch of it be called t, it is well known that the length of that arch will be $= t - \frac{t^3}{3} + \frac{t^5}{5} - \frac{t^7}{7} + \frac{t^9}{9} - \frac{t^{11}}{11}$ + &c. Now, if the affirmative terms of this ſeries be written in one line, and the negative ones in another, the arch will be

$$= \begin{cases} t + \frac{t^5}{5} + \frac{t^9}{9} + \frac{t^{13}}{13} + \frac{t^{17}}{17} + \&c. \\ -\frac{t^3}{3} - \frac{t^7}{7} - \frac{t^{11}}{11} - \frac{t^{15}}{15} - \frac{t^{19}}{19} - \&c. \end{cases}$$

And if, again, the firſt, third, fifth, &c. term of each of theſe ſeries be written in one line, and the ſecond, fourth, ſixth, &c. in another, the ſame arch will be expreſſed thus:

$$= \begin{cases} + \begin{cases} t + \frac{t^9}{9} + \frac{t^{17}}{17} + \frac{t^{25}}{25} + \frac{t^{33}}{33} + \&c. \\ \frac{t^5}{5} + \frac{t^{13}}{13} + \frac{t^{21}}{21} + \frac{t^{29}}{29} + \frac{t^{37}}{37} + \&c. \end{cases} \\ \hline - \begin{cases} \frac{t^3}{3} + \frac{t^{11}}{11} + \frac{t^{19}}{19} + \frac{t^{27}}{27} + \frac{t^{35}}{35} + \&c. \\ \frac{t^7}{7} + \frac{t^{15}}{15} + \frac{t^{23}}{23} + \frac{t^{31}}{31} + \frac{t^{39}}{39} + \&c. \end{cases} \end{cases}$$

All which ſeries are evidently of the firſt form in article 2. and therefore their values may be expreſſed in the ſecond form there given, or more neatly the Newtonian notation mentioned in art. 5. In each of theſe ſeries the value of n is 8:

$$\text{And the value of } m, \left\{\begin{array}{l}\text{in the firſt ſeries, is } 1\,; \\ \text{in the ſecond ſeries, is } 5\,; \\ \text{in the third ſeries, is } 3\,; \\ \text{in the fourth ſeries, is } 7.\end{array}\right.$$

"If now we take $t = \sqrt{\frac{1}{3}}$, the tangent of 30°, which was choſen by Dr Halley, we ſhall have the arch of 30°

$$=\left\{\begin{array}{l} +\left\{\begin{array}{l} \frac{1}{\sqrt{3}}\times:1+\frac{1}{9.81}+\frac{1}{17.81^2}+\frac{1}{25.81^3}+\frac{1}{33.81^4},\ \&c. \\ \frac{1}{9\sqrt{3}}\times;\frac{1}{5}+\frac{1}{13.81}+\frac{1}{21.81^2}+\frac{1}{29.81^3}+\frac{1}{37.81^4},\ \&c. \end{array}\right. \\ \hline -\left\{\begin{array}{l} \frac{1}{3\sqrt{3}}\times:\frac{1}{3}+\frac{1}{11.81}+\frac{1}{19.81^2}+\frac{1}{27.81^3}+\frac{1}{35.81^4},\ \&c. \\ \frac{1}{27\sqrt{3}}\times:\frac{1}{7}+\frac{1}{15.81}+\frac{1}{23.81^2}+\frac{1}{31.81^3}+\frac{1}{39.81^4},\ \&c. \end{array}\right. \end{array}\right.$$

Six timees this quantity will be = the ſemicircumference when radius is 1, and = the whole circumference when the diameter is 1. If therefore we multiply the laſt ſeries by 6, and write $\sqrt{12}$ for $\frac{6}{\sqrt{3}}$, and expreſs their value in the form given in art. 5. we ſhall have the circumference of a circle whoſe diameter is 1,

$$=\left\{\begin{array}{l} +\left\{\begin{array}{l} \frac{81\sqrt{12}}{80}-\frac{8A}{9.80}+\frac{16B}{17.80}-\frac{24C}{25.80}+\frac{32D}{33.80},\ \&c. \\ \frac{81\sqrt{12}}{5.9.80}-\frac{8A}{13.80}+\frac{16B}{21.80}-\frac{24C}{29.80}+\frac{32D}{37.80},\ \&c. \end{array}\right. \\ \hline -\left\{\begin{array}{l} \frac{81\sqrt{12}}{3.3.80}-\frac{8A}{11.80}+\frac{16B}{19.80}-\frac{24C}{27.80}+\frac{32D}{35.80},\ \&c. \\ \frac{81\sqrt{12}}{7.27.80}-\frac{8A}{15.80}+\frac{16B}{23.80}-\frac{24C}{31.80}+\frac{32D}{39.80},\ \&c. \end{array}\right. \end{array}\right.$$

"7. All theſe new ſeries, it is evident, converge ſomewhat ſwifter than by the powers of 80. For in the firſt ſeries, which has the ſloweſt convergency, the coefficients $\frac{8}{9}$, $\frac{16}{17}$, $\frac{24}{25}$, &c. are each of them leſs than 1; ſo that its convergency is ſomewhat ſwifter than by the powers of 80.

"8. But another advantage of theſe new ſeries is, that the numerator and denominator of every term except the firſt, in each of them, is diviſible by 8; in conſequence of which, the arithmetical operation by them is much facilitated, the diviſion by 80 being exchanged for a diviſion by 10, which is no more than removing the decimal point. Theſe ſeries, then, when the factors which are common to both numerators and denominators are expunged, will ſtand as below (each of which ſtill converging ſomewhat quicker than by the powers of 80), and we ſhall have the circumference of a circle whoſe diameter is 1,

$$=\left\{\begin{array}{l} +\left\{\begin{array}{l} \frac{81\sqrt{12}}{80}-\frac{A}{9.10}+\frac{2B}{17.10}-\frac{3C}{25.10}+\frac{4D}{33.10},\ \&c. \\ \frac{9\sqrt{12}}{400}-\frac{A}{13.10}+\frac{2B}{21.10}-\frac{3C}{29.10}+\frac{4D}{37.10},\ \&c. \end{array}\right. \\ \hline -\left\{\begin{array}{l} \frac{9\sqrt{12}}{80}-\frac{A}{11.10}+\frac{2B}{19.10}-\frac{3C}{27.10}+\frac{4D}{35.10},\ \&c. \\ \frac{3\sqrt{12}}{7.80}-\frac{A}{15.10}+\frac{2B}{23.10}-\frac{3C}{31.10}+\frac{4D}{39.10},\ \&c. \end{array}\right. \end{array}\right.$$

"By which ſeries the arithmetical computation will be much more eaſy than by the original ſeries."

Quadrature Lines, or *Lines of Quadrature*, are two lines often placed on Gunter's ſector. They are marked with the letter Q, and the figures 5, 6, 7, 8, 9, 10; of which Q denotes the ſide of a ſquare, and the figures denote the ſides of polygons of 5, 6, 7, &c. ſides. Alſo S denotes the ſemidiameter of a circle, and 90 a line equal to the quadrant or 90° in circumference.

QUADRIPARTITION, is the dividing by 4, or into four equal parts. Hence *quadripartite*, &c. the 4th part, or ſomething parted into four.

QUADRUPLE, is four-fold, or ſomething taken four times, or multiplied by 4; and ſo is the converſe of quadripartition.

QUART, a meaſure of capacity, being the quarter or 4th part of ſome other meaſure. The Engliſh quart is the 4th part of the gallon, and contains two pints. The Roman quart, or quartarius, was the 4th part of their congius. The French, beſides their quart or pot of two pints, have various other quarts, diſtinguiſhed by the whole of which they are quarters; as *quart de muid*, and *quart de boiſſeau*.

QUARTILE, an aſpect of the planets when they are at the diſtance of three ſigns or 90° from each other; and is denoted by the character □.

QUELPAERT, an iſland lying in the mouth of the channel of Japan, and ſubject to the king of COREA (See that article *Encycl.*) Till the laſt voyage of La Perouſe, this iſland was known to Europeans only by the wreck of the Dutch ſhip Sparrow-hawk in 1635. On the 21ſt of May 1787, the French Commodore made this iſland, and determined the ſouth point of it to be in Lat. 33° 14′ north, and in Lon. 124° 15′ eaſt from Paris. He ran along the whole ſouth eaſt ſide, at ſix leagues diſtance, and ſays that it is ſcarcely poſſible to find an iſland which affords a finer aſpect; a peak of about a thouſand toiſes, which is viſible at the diſtance of eighteen or twenty leagues, occupies the middle of the iſland, of which it is doubtleſs the reſervoir; the land gradually ſlopes towards the ſea, whence the habitations appear as an amphitheatre. The ſoil ſeemed to be cultivated to a very great height. By the aſſiſtance of glaſſes was perceived the diviſion of fields; they were very much parcelled out, which is the ſtrongeſt proof of a great population. The very varied gradation of colours, from the different ſtates of cultivation, rendered the view of this iſland ſtill more agreeable. Unfortunately, it belongs to a people who are prohibited from all communication with ſtrangers, and who detain in ſlavery thoſe who have the misfortune to be ſhipwrecked on theſe coaſts. Some of the Dutchmen of the ſhip Sparrow-hawk, after a captivity of eighteen years there, during which they received many baſtinadoes, found means to take away a bark, and to croſs to Japan, from which they arrived at Batavia, and afterwards at Amſterdam.

QUEUE D'ARONDE, or *Swallow's Tail*, in fortification, is a detached or outwork, whoſe ſides ſpread or open towards the campaign, or draw narrower and cloſer towards the gorge. Of this kind are either ſingle or double tenailles, and ſome horn-works, whoſe ſides are not parallel, but are narrow at the gorge, and open at the head, like the figure of a ſwallow's tail. On the contrary, when the ſides are leſs than the gorge, the work is called *contre queue d'aronde.*

Queue, Quintal

Queue d'aronde, in carpentry, a method of jointing, called alſo *dove-tailing*.

QUINTAL, the weight of a hundred pounds, in moſt countries: but in England it is the hundred weight, or 112 pounds. Quintal was alſo formerly uſed for a weight of lead, iron, or other common metal, uſually equal to a hundred pounds, at 6 ſcore to the hundred.

Quintile.

QUINTILE, in aſtronomy, an aſpect of the planets when they are diſtant the 5th part of the zodiac, or 72 degrees; and is marked thus, C, or Q.

R.

Rachitis.

RACHITIS, RICKETS (See MEDICINE-*Index*, *Encycl.*), is a diſeaſe ſo formidable to children, that we believe no parent will think the following abſtract of *Bonhomme*'s memoir on the nature and treatment of it too long even for this *Supplement*.

The change which the bones undergo in this diſorder, has long been attributed to the action of an acid on their ſubſtance; but this ſuppoſition was grounded on mere conjecture and remote analogy. Bonhomme holds the ſame opinion on better grounds; and the principal notions which conſtitute the baſis of his memoir are the following:

1. According to him, the nature of the rachitic diſorder ariſes, on the one hand, from the developement of an acid approaching in its properties to the vegetable acids, particularly the oxalic; and, on the other, from the defect of phoſphoric acid, of which the combination with the animal calcareous earth forms the natural baſis of the bones, and gives them their ſolidity. Whence it follows, that the indication reſulting from this propoſition, if once adopted, would be, that the treatment of rachitis muſt depend on two principal points, namely, to prevent the developement of the oxalic acid, and to re-eſtabliſh the combination of the phoſphoric acid with the baſis of the bones to which they owe their ſolidity.

2. The author proves, by experiments and obſervations, in the firſt place, that alkaline lotions of the parts affected with rachitis contribute to their cure; next, that the calcareous phoſphate taken internally is really tranſmitted by the lymphatic paſſages, and contributes to oſſification; and, laſtly, that the internal uſe of calcareous phoſphate, whether alone or combined with the phoſphate of ſoda, powerfully contributes to reſtore the natural proportions in the ſubſtance of the bones, and accelerate the cure of rachitis.

With regard to the author's endeavours to prove that the calcareous acid is wanting in the bones of thoſe who are diſordered with rachitis, and that the developement of oxalic acid contributes to the diſeaſe, we muſt not conceal that his memoir contains views rather than abſolute proofs of theſe two poſitions. He declares, himſelf, he was not provided with the neceſſary means to eſtabliſh an exact and complete analyſis. He therefore preſents his ideas, in this reſpect, merely as conjectures approaching to the truth.

The effect of the action of acids upon bones was before known; that is to ſay, that when deprived of calcareous phoſphate, and reduced to the gelatinous parenchyma which forms one of their elements, they loſe their conſiſtence, and become flexible. Hence it was already conjectured by various phyſicians, that the rachitis was the effect of a peculiar acid.

A diſpoſition to aceſcence in the firſt paſſages is obſervable in all infants. The odour which characterizes this aceſcence is often manifeſt in their breath, and even their perſpiration. The bile corrects this diſpoſition; but in general the bile is wanting in rachitic infants. It does not colour their excrements, and the acids accordingly are developed in a very decided manner. They diſturb the circulation, and attack and ſoften the bones. As it is by defect of animalization that theſe acids develope themſelves, it follows that their character is analogous to the fermenteſcible vegetable acids, and more or leſs to the oxalic acid; and that, on the contrary, the animal acid or phoſphoric acid ceaſes to be formed, and to unite with the animal calcareous earth; whence they are deprived of the principle of their ſolidity. This is the theory of Citizen Bonhomme.

In order to eſtabliſh this doctrine upon preciſe experiments, it was requiſite to analyſe rachitic bones comparatively with thoſe of healthy individuals of the ſame age; and as it is known that the urine of rachitic ſubjects depoſites a great quantity of a ſubſtance of ſparing ſolubility and earthy appearance, it would have been advantageous to have joined a complete analyſis of this urine and its ſediment. Citizen Bonhomme, not being provided with the means ſufficient to make theſe analyſes, and being beſides of opinion that ſuch rachitic bones as are deſtroyed by this malady exiſt in a progreſſive ſtate of change, which might render their analyſis ſcarcely ſuſceptible of compariſon, limited himſelf to a collection of ſome of the moſt remarkable phenomena of the urine, of the aged, the adult, and infants in the healthy ſtate, of infants in the rachitic ſtate, and of patients after the perfect cure of this diſorder. From theſe obſervations he has deduced ſeveral important reſults.

It is known, that when the urine contains diſengaged phoſphoric acid, as happens to aged individuals, and in ſome peculiar circumſtances of the ſyſtem, if lime water be poured in, there is a ſpeedy depoſition of calcareous phoſphate. It is alſo known, that when a ſolution of the nitrate of mercury is poured to the freſh urine of adults, a roſe-coloured precipitate is formed, which is a phoſphate of mercury produced by the decompoſition of the phoſphates contained in the urine. Theſe two proofs are therefore extremely proper to aſcertain the preſence of phoſphoric acid, whether free or combined, in a fluid which in its natural ſtate contains a remarkable proportion. Beſides this principle, the urine depoſits more or leſs of ſediment, either gelatinous or of an earthy appearance; and, laſtly, by evaporation, a ſaponaceous and ſaline extract, in greater or leſs abundance, is obtained by evaporation. By means of theſe four methods of examination, the author has aſcertained the following facts:

1. In the healthy ſtate, the ſediment naturally depoſited by urine is almoſt totally gelatinous in the infant and the adult, and in the aged individual it is ſurcharged with an abundant ſediment of an earthy appearance ſimilar to the earth of bones, which conſequently is calcareous phoſphate. 2. The quantity of brown ſaponaceous ſaline extract afforded by evaporation is greater in proportion to the age. 3. The preſence of diſengaged phoſphoric acid, as ſhewn by lime water, is none in the urine of infants, ſcarcely perceptible in that of adults, but very remarkable in that of old men. For two ounces of this laſt urine afforded by this means ten grains of phoſphate of lime. 4. The decompoſition of the phoſphates by nitrate of mercury is not ſeen in the urine of infants; an abundant precipitate of a light roſe-colour is produced in this way from the urine of adults; and in that of old men this precipitate is always of a grey colour, and very abundant. Hence Citizen Bonhomme concludes, that the phoſphoric acid, whether at liberty or combined, does exiſt in the urine of healthy individuals in proportion to the deſtruction of the ſolids by age, and that it increaſes with the age.

With regard to the urine of rachitic ſubjects, the moſt remarkable facts are, 1. The abundant and apparently earthy ſediment it depoſits (ſpontaneouſly) is different from that of old men, by its colour, which is grey, and does not reſemble phoſphate of lime, and alſo by its much greater quantity. For a pound of this urine let fall two gros, whereas the ſame quantity of the urine of old men depoſited only 45 grains. 2. The extract left by evaporation is likewiſe much more conſiderable than in other urine. It is one-third more in quantity than the extract afforded even by the urine of aged perſons.

From theſe two firſt obſervations it follows, that the ſolids in rachitic ſubjects are deſtroyed with much more rapidity than even in old men; and that they afford a much more abundant portion of waſte to the urine.

3. The light depoſition occaſioned by lime water in the urine of rachitic ſubjects is very ſmall in quantity, brown, gelatinous when freſh, and pulverulent when dry. It does not at all reſemble calcareous phoſphate. 4. The depoſition formed by the ſolution of mercurial nitrate is not abundant, neither of a roſe colour as in the urine of adults, nor grey like that of old men. It is always white, and conſequently has no external reſemblance to the phoſphate of mercury. The author affirms that it reſembles a mercurial oxalate. Laſtly, the urine of the ſame rachitic ſubjects when cured, exhibits again all the characters obſerved in the urine of healthy children. We ſhall not add to the reflections of the author. In effect, though theſe firſt obſervations are curious, they are incomplete. We offer them to phyſicians ſimply as the elements of an inveſtigation which it is of importance to continue and bring to perfection. We ſhall therefore proceed to the curative and experimental parts of the memoir.

One of the facts which it was of the utmoſt importance to eſtabliſh, was the tranſition of the calcareous phoſphate from the inteſtinal paſſages, into thoſe of circulation and ſecretion. Fourcroy had already well aſcertained that the ſerum of milk contains this ſalt naturally. Vauquelin had proved its exiſtence, as well as that of pure ſoda, in the ſeminal fluid; but was it poſſible that it could paſs unaltered from the ſtomach and inteſtines into the veſſels which contain the blood and lymph? Could it by this means apply itſelf to the bones? This was to be aſcertained by experiments; and the following are the experiments made by Bonhomme for that purpoſe. We give them in a tranſlation of his own words.

"I cauſed (ſays he) ſeveral young fowls of the ſame incubation to be fed in different manners. Some received the uſual food without any mixture; others received daily a certain quantity of calcareous phoſphate mixed in the ſame paſte as formed the ſupport of the others; and, laſtly, one of them was fed with variations in the uſe of the mixture: the calcareous phoſphate was ſometimes given and ſometimes ſuſpended. When theſe fowls, after two months, had acquired their ordinary growth, I examined and carefully compared the ſtate of their bones. The progreſs of the oſſification in the epiphyſes was various according to the nature of the food the animal had received. The bones of the laſt fowl, which had received the phoſphate only from time to time, were rather more advanced than the bones of thoſe which had been fed without mixture. The bones of thoſe fowls which had been habitually fed with the mixture were evidently more ſolid, and their epiphyſes were much leſs perceptible. Simple inſpection was ſufficient to ſhew theſe differences when the bones were mixed together.

"I had fed ſeveral young fowls of the ſame incubation according to another plan. Some were fed on a ſimple paſte, without mixture; for others it was mixed with pulveriſed madder-root; and a third compoſition was made of this laſt paſte and calcareous phoſphate. This was alſo given habitually to other fowls. When after two months I examined the progreſs of oſſification in the bones of theſe different animals, I eaſily perceived the red traces of the madder in the oſſified parts of all thoſe which had uſed it; but I obſerved, that the oſſification was not more advanced by the ſimple mixture of this root than by the ordinary food: on the contrary, the bones of thoſe fowls which had ſwallowed the phoſphate mixed with madder were much more ſolid than the others. The red colour ſerved admirably to diſtinguiſh the extremities of the long bones from their epiphyſes. After an exact compariſon, there could be no doubt of the efficacy of calcareous phoſphate in favour of the progreſs of oſſification. The virtue of the madder ſeemed confined to that of giving colour to the oſſified parts."

From theſe experiments, it was natural to make the trial of calcareous phoſphate in addition to the remedies made uſe of in the treatment of rachitic ſubjects. Here follows what the author himſelf ſays of two remarkable inſtances in which the calcareous phoſphate was adminiſtered with ſucceſs:

"The daughter of Mr Ranchon watch-maker, aged two years and a half, walked with a feeble and tottering pace, and the extremities of all her bones preſented epiphyſes very prominent. In this ſituation ſhe exhibited the appearance of imperfect rachitis, or the firſt period of this diſorder. Alkaline lotions, which I immediately adviſed, were attended with a good effect. Her ſleep became more firm; and as the firſt paſſages were in a good ſtate, I gave, without internal preparation, one ſcruple of a mixture of equal parts of phoſphate of lime and phoſphate of ſoda twice a-day. In the courſe of three weeks her legs were perfectly reſtored; and this amiable infant has ever ſince had the ſatisfaction to run with ſpirit and agility.

"A female infant, of the name of Boiard, aged four years, had experienced from her birth the moſt decided ſymptoms of rachitis. The protuberance of the epiphyſes and tumefaction of the abdomen firſt indicated the diſeaſe. The impoſſibility of ſupporting herſelf and walking at the uſual age confirmed theſe unfortunate ſymptoms. By degrees the glands of the neck and of the meſentery became ſwelled; the teeth were blackened, became carious, and were not replaced. This ſituation became ſtill more afflicting by criſes almoſt periodical at an interval of three or four weeks. At theſe afflicting periods, a fever of conſiderable ſtrength, cardialgia, and even convulſions, particularly in the night, were obſerved. The termination of each paroxyſm was announced or aſcertained by abundant ſtools, and the evacuation of urine ſtrongly charged with an earthy ſediment. The imprudent exhibition of a purge at the beginning of one of theſe criſes had nearly deprived the patient of her life. In this ſtate it was that I beheld her for the firſt time in the month of January 1791. The alkaline lotion was the only remedy the mother adopted in the firſt inſtance, and it produced a remarkable effect. After eight days the infant was ſo much better as to be able to ſupport herſelf. The remedy was then laid aſide, and eight days afterwards the child was incapable of ſtanding without ſupport. The uſe of the alkaline ſolution being renewed, was attended with the ſame ſucceſs, and its diſcontinuance was again followed by the complete return of all the ſymptoms. In the firſt days of March, the other remedies I had adviſed were exhibited. The conſtipation which had always exiſted became leſs, and the following criſis was effected without pain. And at length the convulſions, the pains, and the criſes diſappeared; but the impoſſibility of walking ſtill remained. At this time, namely on the ſecond of May, I gave the child the phoſphate of ſoda and calcareous phoſphate mixed together, in the doſe of half a dram twice a-day. At the end of the month ſhe was able to ſtand upright, leaning againſt a chair, and the ſwellings began to diminiſh. She continued for a long time afterwards to take the mixture of the phoſphates. I likewiſe gave her occaſionally one grain of the extract of bile, prepared with ſpirit of wine; and at length in the month of July I had the pleaſure to ſee the patient run and play in the middle of the ſtreet with the other children of her own age, &c."

The author gives other inſtances of this medicine being adminiſtered with complete ſucceſs to rachitic children, and one in which it was attended with the beſt effects in a caſe of incurvated ſpine. Theſe it is needleſs to inſert, becauſe we truſt that none of our leſs learned readers will have recourſe to the medicine without the advice of a phyſician; and to him an enumeration of caſes could ſerve no purpoſe. It may be proper, however, as alkaline lotions and their beneficial effects are mentioned, to give here the author's account of the lotion which he uſed.

"In ordinary caſes of rachitis, particularly at the commencement of the diſorder, it is of advantage to uſe a ſimple ſolution of pot-aſh to waſh the parts affected. This ſolution is made by diſſolving from half an ounce to an ounce of purified pot-aſh in a pound of diſtilled or very pure ſpring water. When it is to be uſed, the ſkin muſt firſt be rubbed with a dry cloth, or a piece of fine flannel. After this precaution, the diſeaſed extremities are to be waſhed carefully with the warm ſolution, and at length wiped, ſo as to leave no trace of moiſture. This practice and waſhing muſt be repeated at leaſt twice a-day. I can affirm, from repeated trials, that it will ſoon be attended with ſucceſs."

In a note on this paſſage, M. Hallé, who analyſed the memoir at the deſire of the Society of Medicine at Paris, juſtly obſerves, that as pure potaſs, or the vegetable alkali, is a moſt powerful cauſtic, it cannot be uſed in theſe proportions; adding, that he found one-eighth part of the ſalt here indicated to form too ſtrong a lotion for the ſkin of an infant. M. Bonhomme, upon enquiry being made, informed him, that the potaſs which he uſed was that of the ſhops, which is very far from being pure; and Mr Nicholſon conjectures that it was the common ſalt of tartar of our ſhops. This, we think, extremely probable, eſpecially as M. Bonhomme aſſures us that even a lixium of wood-aſhes, ſuch as is uſed for waſhing fine linen, may anſwer the purpoſe extremely well.

For a fuller account of this intereſting memoir our readers are referred to the 17th volume of the *Annals de Chimie*, or to the firſt volume of *Nicholſon's Philoſophical Journal*.

RAJA, the *ray fiſh*. See *Encyclopædia*, where it is ſaid that the *oxyrinchus* or ſharp noſed ray, is ſuppoſed to be the *bos* of the ancients; but if there be any truth in the following narrative, which we confeſs has much the air of fiction, this is probably a miſtake. It is the narrative of Vaillant, and we ſhall give it in his own words.

"In the latitude 10° 15′ north, and longitude 355°, an enormous flat fiſh of the ray genus (ſays he), came and ſwam round our veſſel. It differed from the common ray, however, in the ſhape of its head, which, inſtead of being pointed, formed a creſcent, and from the extremities of the ſemicircle iſſued two arms as it were, which the ſailors called horns. They were two feet wide at the baſe, and only five inches at the extremity. This monſter they told me was called the *ſea-devil*.

"A few hours after, we ſaw two others with this, one of which was ſo extremely large, that it was computed by the crew to be *fifty* or *ſixty* feet wide. Each ſwam ſeparately, and was ſurrounded by thoſe ſmall fiſh which uſually precede the ſhark, and which are therefore called by ſeamen *pilot-fiſh*. Laſtly, all three carried on each of their horns a white fiſh, about the ſize of a man's arm, and half a yard long, which appeared to be ſtationed there on duty.

"You would have ſaid they were two ſentinels placed to keep watch for the ſafety of the animal, to inform him of any approaching danger, and to guide his movements. If he approached too near the veſſel, they quitted their poſts, and, ſwimming briſkly before, led him away. If he roſe too high above the water, they paſſed backward and forward over his back till he had deſcended deeper. If, on the contrary, he ſwam too low, they diſappeared, and we ſaw no more of them, becauſe, no doubt, they were paſſing underneath, as in the preceding inſtance they had paſſed above him. Accordingly we found him re-aſcend towards the ſurface, and then the two ſentinels reaſſumed their poſts, each on his horn."

Theſe manœuvres continued three days; and to give our author the better opportunity of obſerving them, the ſhip moſt fortunately was becalmed the whole time. He was naturally very deſirous of catching one of them that he might examine it at leiſure; and, by bribing the ſeamen with a dozen of bottles of wine, he accompliſhed his object. One of the fiſh was ſtruck with twelve or fifteen harpoons; ſeveral halſers were paſſed round his body, and he was hoiſted on board.

" This (ſays our author) was the leaſt of the three, being only *eight-and-twenty* feet in its extreme breadth, and *one-and twenty* in length from the extremity of the horns to that of the tail. The tail, which was thick in proportion to the body, was *twenty-two inches* long. The mouth, placed exactly like that of the ray, was wide enough to ſwallow a man with eaſe. The ſkin was white under the belly, and brown on the back, like that of the ray. We reckoned the animal to weigh not leſs, certainly, than a ton."

We think it was fortunate that they chanced to ſtrike the ſmalleſt fiſh; for an addition of eight or ten ton weight, which the largeſt ray muſt have weighed, as certainly as the ſmalleſt weighed one ton, might have been very inconvenient on board a ſhip already loaded. We do not remember to have anywhere met with a deſcription of this ray before, and we think it ſhould be conſidered as a new ſpecies; but we ſhall not give it a name till its exiſtence be better aſcertained, when we ſubmit to the pupils of Linnæus, whether it may not be proper to give it the ancient name *bos*.

RAJAH. (See *Encyclopedia.*) We learn from Sir Charles Rouſe Boughton's *Diſſertation concerning the Landed Property of Bengal*, that this title is conferred upon Hindoos by the emperor, and frequently given out of courteſy to the greater zemindars. It would appear therefore that the Rajahs can never be independent of the Mogul but by a ſucceſsful rebellion.

RAYEI-UL-MULK, in the language of Bengal, the uſage of the country, the common law.

RATIO (See *Encyclopædia*) has been defined by Euclid, in the 5th book of his Elements, in terms to which many mathematicians have objected; and his definition of proportion, which is ſo ultimately connected with it, is ſtill more objectionable. The Rev. Abraham Robertſon of Oxford, in a ſmall tract publiſhed in 1789, demonſtrates the truth of the two definitions in queſtion in ſeven propoſitions, of which the ſubſtance is as follows. He firſt lays down theſe four definitions:

" 1. Ratio is the relation which one magnitude has to another, of the ſame kind, with reſpect to quantity.

" 2 If the firſt of four magnitudes be exactly as great when compared to the ſecond, as the third is when compared to the fourth, the firſt is ſaid to have to the ſecond the ſame ratio that the third has to the fourth.

" 3. If the firſt of four magnitudes be greater, when compared to the ſecond, than the third is when compared to the fourth, the firſt is ſaid to have to the ſecond a greater ratio than the third has to the fourth.

" 4. If the firſt of four magnitudes be leſs, when compared to the ſecond, than the third is when compared to the fourth, the firſt is ſaid to have to the ſecond a leſs ratio than the third has to the fourth."

He then demonſtrates, by reaſoning ſtrictly geometrical, the following propoſitions:

Prop. 1. If the firſt of four magnitudes have to the ſecond, the ſame ratio which the third has to the fourth; then, if the firſt be equal to the ſecond, the third is equal to the fourth; if greater, greater; if leſs, leſs.

Prop. 2. If the firſt of four magnitudes be to the ſecond as the third to the fourth, and if any equimultiples whatever of the firſt and third be taken, and alſo any equimultiples of the ſecond and fourth; the multiple of the firſt will be to the multiple of the ſecond as the multiple of the third to the multiple of the fourth.

Prop. 3. If the firſt of four magnitudes be to the ſecond as the third to the fourth, and if any like aliquot parts whatever be taken of the firſt and third, and any like aliquot parts whatever of the ſecond and fourth, the part of the firſt will be to the part of the ſecond as the part of the third to the part of the fourth.

Prop. 4. If the firſt of four magnitudes be to the ſecond as the third to the fourth, and if any equimultiples whatever be taken of the firſt and third, and any whatever of the ſecond and fourth; if the multiple of the firſt be equal to the multiple of the ſecond, the multiple of the third will be equal to the multiple of the fourth; if greater, greater; if leſs, leſs.

Prop. 5. If the firſt of four magnitudes be to the ſecond as the third is to a magnitude leſs than the fourth, then it is poſſible to take certain equimultiples of the firſt and third, and certain equimultiples of the ſecond and fourth, ſuch, that the multiple of the firſt ſhall be greater than the multiple of the ſecond, but the multiple of the third not greater than the multiple of the fourth.

Prop. 6. If the firſt of four magnitudes be to the ſecond as the third is to a magnitude greater than the fourth, then certain equimultiples can be taken of the firſt and third, and certain equimultiples of the ſecond and fourth, ſuch, that the multiple of the firſt ſhall be leſs than the multiple of the ſecond, but the multiple of the third not leſs than the multiple of the fourth.

Prop. 7. If any equimultiples whatever be taken of the firſt and third of four magnitudes, and any equimultiples whatever of the ſecond and fourth; and if when the multiple of the firſt is leſs than that of the ſecond, the multiple of the third is alſo leſs than that of the fourth; or if when the multiple of the firſt is equal to that of the ſecond, the multiple of the third is alſo equal to that of the fourth; or if when the multiple of the firſt is greater than that of the ſecond, the multiple of the third is alſo greater than that of the fourth: then, the firſt of the four magnitudes ſhall be to the ſecond as the third to the fourth.

RATIONAL, in arithmetic, &c. the quality of numbers, fractions, quantities, &c. when they can be expreſſed by common numbers; in contradiſtinction to irrational or ſurd ones, which cannot be expreſſed in common numbers.

RAYNAL (William Thomas), commonly called the Abbé Raynal, was educated among the Jeſuits, and had become one of the order. The learning of that Society is univerſally known, as well as the happy talents which its ſuperiors poſſeſſed, of aſſigning to each member his proper employment. Raynal, however, after having acquired among them a taſte for literature and ſcience, had probably become refractory, for he was expelled from the order; and the cauſe of his expulſion, according to the Abbé Barruel, was his impiety.

With the real cauſe of his expulſion M. Barruel is ſurely much better acquainted than we can pretend to be; but we have a ſtrong ſuſpicion that his impieties had not then reached farther than to call in queſtion the ſupreme authority of the church; for our author himſelf aſſures us, that he did not utter his atrocious declarations againſt Chriſtianity till he had ceaſed to be a member of the order of Jeſuits. He then aſſociated himſelf with Voltaire, D'Alembert, and Diderot, and was by them employed to furniſh the theological articles for the *Encyclopédie*. But though his religious opinions were certainly lax, and his moral principles very exceptionable, he could not even then be what, in a Proteſtant country, would be deemed a man remarkable for impiety; for he employed the Abbé Yvon, whom M. Barruel calls an odd metaphyſician, but an inoffenſive and upright man, to write the articles which he was engaged to furniſh. In the conducting of this tranſaction, he ſhewed, indeed, that he poſſeſſed not a proper ſenſe of honour; for he paid poor Yvon with twenty-five louis d'ors for writing theological articles, for which he received himſelf ſix times that ſum. This trick was diſcovered, Raynal was diſgraced, and compelled to pay up the balance to Abbé Yvon; but tho' he had thus ſhewn himſelf to be without honour, it is difficult to believe that he had yet proceeded ſo far as to blaſpheme Chriſt, ſince he had employed a Chriſtian divine to ſupply his place in the *Encyclopédie*.

His firſt work of eminence, and that indeed upon which his fame is chiefly built, is his "Political and Philoſophical Hiſtory of the European Settlements in the Eaſt and Weſt Indies." That this hiſtory is written in an animated ſtyle, and that it contains many juſt reflections, both political and philoſophical, is known to all Europe; for it has been tranſlated into every European language. Its beauties, however, are deformed by many ſentiments that are irreligious, and by ſome that are impure. It was followed, we think, in 1780, by a ſmall tract entitled "The Revolution of America;" in which the author pleads the cauſe of the revolted coloniſts with a degree of zeal, cenſures the conduct of the Britiſh government with a keenneſs of aſperity, and diſplays a knowledge of the principles and intrigues of the different factions which at that period divided the Engliſh nation, that ſurely was not natural to the impartial pen of a philoſophic foreigner. Hence he has been ſuppoſed to have been incited to the undertaking, and to have been furniſhed with part of his materials, by that deſperate faction which uniformly oppoſed the meaſures of Lord North, and ſecretly fomented the rebellion in America. Be this as it may, he propagated, both in this tract and in his hiſtory, a number of licentious opinions reſpecting government and religion, of which he lived to regret the conſequences.

A proſecution was inſtituted againſt him by the French government on account of his hiſtory of the Eaſt and Weſt Indies; but it was conducted with ſo little ſeverity, that he had ſufficient time to retire to the dominions of the King of Pruſſia, who afforded him the protection he ſolicited, although his Majeſty's character was treated by the author in his book with no great degree of veneration. Raynal alſo experienced the kindneſs of the Empreſs of Ruſſia; and it is not a little remarkable of this ſingular perſonage, that, although he was always ſevere in diſcuſſing the characters of princes, yet the moſt deſpotic among theſe heaped upon him many marks of favour and generoſity. The Abbé alſo received a very unuſual mark of reſpect from a Britiſh Houſe of Commons. It was once intimated to the ſpeaker that Raynal was a ſpectator in the gallery. The buſineſs was immediately ſuſpended, and the ſtranger conducted to a more convenient and honourable ſituation. How different was the conduct of Dr Johnſon, who, when a friend advanced to him with our author, ſaying, "Will you give me leave, Doctor, to introduce to you the Abbé Raynal?" turned on his heel, and vociferated, "No, Sir!" We are far from wiſhing to vindicate the rudeneſs of the ſage; but it was perhaps as proper as the politeneſs of the Houſe of Commons.

The great trait of Raynal's character was a love of liberty, which, in his earlier writings, he did not properly define; but when he lived to ſee ſome of the conſequences of this, in the progreſs of the French Revolution, he made one glorious effort to retrieve his errors. In the month of May 1791, he addreſſed to the conſtituent aſſembly one of the moſt eloquent, argumentative, and impreſſive letters that ever was written on any ſubject; a letter which, if the majority of them had not been intoxicated with their newly acquired conſequence, muſt have given ſome check to their mad career. After complimenting them upon what they had done, he proceeds thus: "I have long dared to ſpeak to kings of their duty; ſuffer me now to ſpeak to the people of their errors, and to their repreſentatives of the dangers which threaten us. I am, I own to you, deeply afflicted at the crimes which plunge this empire into mourning. Is it true that I am to look back with horror at myſelf for being one of thoſe who, by feeling a noble indignation againſt arbitrary power, may perhaps have furniſhed arms to licentiouſneſs? Do then religion, the laws, the royal authority, and public order, demand back from philoſophy and reaſon the ties which united them to the grand ſociety of the French nation, as if, by expoſing abuſes, and teaching the rights of the people and the duties of princes, our criminal efforts had broken thoſe ties? But, no!—never have the bold conceptions of philoſophy been repreſented by us as the ſtrict rule for acts of legiſlation.

"You cannot juſtly attribute to us what could only be the reſult of a falſe interpretation of our principles. Alas! now that I ſtand on the brink of the grave; now that I am about to quit this immenſe family, whoſe happineſs I have ardently deſired, what do I ſee around me? Religious troubles, civil diſſenſions, conſternation on the one hand, tyranny and audacity on the other; a government the ſlave of popular tyranny; the ſanctuary of the laws ſurrounded by unruly men, who alternately dictate or deſpiſe thoſe laws; ſoldiers without diſcipline; leaders without authority; miniſters without means; a king, the firſt friend of his people, plunged into bitterneſs, inſulted, menaced, ſtripped of all authority; and the public power no longer exiſting but in clubs, in which ignorant and rude men dare to decide all political queſtions."

He then proceeds to prove, which he does very completely, that it was not the buſineſs of the aſſembly to aboliſh every ancient inſtitution; that the genius of the French people is ſuch, that they never can be happy or proſperous but under a well-regulated monarchical government; and that, if they wiſhed not the nation to fall under the worſt kind of deſpotiſm—the deſpotiſm of a low faction, they muſt increaſe the power of the king. "Alas! (continues he) what are my ſufferings, when in the heart of the capital, in the centre of knowledge, I ſee this miſguided people welcome, with a ferocious joy, the moſt criminal propoſitions, ſmile at the recital of murder, and celebrate their crimes as conqueſts!"

He had then ſeen comparatively but little; but he lived to ſee more—to ſee his countrymen celebrate, as virtues, crimes, compared with which the atrocities of 1790 appear almoſt as harmleſs. Being ſtripped of all his property, which was large, by the robbers of the revolution, he died in poverty in March 1796, and in the 84th year of his age.

Beſides the works which we have already mentioned, he wrote "A Hiſtory of the Parliament of England," and a "Hiſtory of the Stadholderate;" but theſe are both of them more remarkable for a ſpecious ſtyle and loftineſs of invention than for uſeful obſervation or ſolid argument. He wrote likewiſe "The Hiſtory of the Divorce of Catharine of Arragon by Henry the Eighth," which is not ſo much a recital of, and commentary upon, the fact from which he takes the title, as it is an able picture of univerſal Europe at that period, of the views, intereſts, and power, of all the different potentates. At the time of his death he was preparing a new edition of all his works, in which were to be made many alterations; and he is ſaid to have left among his manuſcripts a "Hiſtory of the Revocation of the Edict of Nantes," in four volumes; but it is alſo very certain, that, during the ſanguinary reign of Robeſpierre, he burnt a great part of his papers.

REAPING, the well-known operation of cutting corn either by the ſickle or by the ſcythe. Reaping by the ſickle is by much the moſt common practice, and that which, we believe, prevails univerſally in Scotland; yet the other method, where it is practicable, is certainly the leaſt laborious, and by much the moſt expeditious. To the ſcythe, as an inſtrument of reaping, many objections are urged.

It is ſaid that it ſhakes the ear, ſo that many of the grains are loſt; that it lets the corn fall, after cutting it, in a confuſed and ſcattered ſtate, ſo that either much of it is loſt, or a great deal of time is conſumed in gathering it together; that it can only be made uſe of in land which is very even and free from ſtones; that it does not leave ſufficient length of ſtubble in the ground to lay the corn on when cut; that it mixes bad weeds with the corn, the ſeeds of which are ſown the next year; and, laſtly, that the uſe of the ſcythe is prejudicial to the health of the reaper.

Theſe objections, however, are either of no weight, or they are made by thoſe who are not acquainted with the ſcythes which have been adapted to this purpoſe, and with the proper manner of uſing them. With a good ſcythe, properly managed, the corn, after being cut, remains at firſt upright, and then falls very gently upon the rake fixed to the ſcythe, without any ſhake or jolt; or at leaſt with leſs than that which it receives when reaped with a ſickle. With reſpect to the loſs of grain, that proceeds chiefly from the corn being too dry; conſequently it ſhould be reaped only upon proper days, and proper times of the day, which is much more eaſily done with the ſcythe than with the ſickle, becauſe the work is ſo much ſhorter. The ſtalks, kept together by the rake, may be laid upon the ground, or rather againſt the corn not yet cut, in ſo regular and collected a ſtate, that thoſe who gather and tie the ſheaves, whether they are women or children, have nothing but their own negligence to accuſe if any thing is left behind. When land is properly ploughed and harrowed, it is ſufficiently even; and in ſuch as is ſtony, the only precaution neceſſary is to keep the ſcythe a little higher in uſing it, that it may not ſtrike againſt the ſtones. If the ſtubble left in the ground be ſhort, the ſtraw which is cut off will be the longer; and the latter is certainly of more value than the former, which only ſerves to incommode the cattle which afterwards go to feed in the field.

Theſe conſiderations, and others of a like nature, induced the patriotic ſociety of Milan to ſend, ſome years ago, to thoſe parts in which ſcythes are made uſe of for reaping; and having procured a model of a ſcythe from Sileſia, they cauſed one to be made of a proper ſize. It was firſt tried upon corn, and afterwards upon millet; and although the firſt ſcythe was not accurately made, and the reaper had never before made uſe of ſuch an inſtrument, yet it was found that nearly half the uſual time was ſaved, and that the labour and fatigue were much diminiſhed; the corn alſo was cut without receiving any ſhock that could be hurtful to it, and fell in an even and regular ſtate, ſo that it was afterwards eaſily bound up in compact ſheaves. They were afterwards preſented with a ſcythe ſomewhat different from the Sileſian, which is very generally uſed in Auſtria.

Plate XLII.

Theſe inſtruments are ſo ſimple, that the figure of one of them renders the deſcription of either almoſt unneceſſary. In fig. 1. is ſhewn the Sileſian ſcythe tried by the Society; the difference between that and the Auſtrian one we ſhall mention in our deſcription. The firſt, or Sileſian ſcythe, differs very little from the ſcythe we commonly uſe for mowing graſs, except that the blade is rather ſmaller; to it are added four teeth of wood, parallel to the blade, fixed and ſecured in a proper manner, and intended to keep the corn together after being cut, ſo that inſtead of its falling in a confuſed ſtate, the reaper may lay it down in a regular and compact one. The ſecond, or Auſtrian ſcythe, is ſimilar to the former, except that the blade is larger; conſequently the wooden teeth, of which there are five, are longer; the handle alſo is more flat, and rather crooked.

In the *firſt*, the handle *a b* (ſee fig. 1.) is two Milaneſe braſſes (A), and nine inches and a half in length; the

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(A) One hundred Milaneſe *braſſes* are equal to fifty-eight Engliſh yards and a half.

the blade *b c* is one braſs three inches and a half; the piece of wood in which the teeth are fixed, one braſs one inch and a half. In the *ſecond*, the handle is two braſſes, and ſeven inches long; the blade, one braſs eleven inches; the piece in which the teeth are fixed, eleven inches and a quarter. The proportions of the other parts may be conceived from the figure.

The difference in the conſtruction of theſe two ſcythes makes it requiſite to uſe them in a different manner; but that will be better acquired in practice than by precept. Such of our countrymen as are accuſtomed to the uſe of the common ſcythe will very ſoon find out the moſt convenient and advantageous manner of uſing theſe new kinds of ſcythe, and of laying down the corn properly when cut.

It ſhould, however, be obſerved, that in mowing graſs the feet are kept almoſt parallel to each other, whereas in reaping corn they ſhould be kept upon a line, one behind the other, thruſting the right foot forward, and drawing the left towards it. This is neceſſary, becauſe when graſs is mowed it is left to fall juſt where it is cut; but when corn is cut, it is to be carried and laid in a proper manner againſt that which is not yet cut, and which is at the left hand of the reaper; and if the feet were kept parallel to each other, the reaper would be obliged to extend and turn his body in a very inconvenient manner.

After having made public theſe obſervations, the ſociety made farther experiments upon the ſubject; in which it was found, that when, on account of very wet weather, the ſtalks of the corn are bent down, the wooden teeth of the forementioned ſcythes are apt to lay hold of ſome ears, to the ſtalks of which the iron does not reach, and conſequently not being cut below, they are pulled ſo, that the grain is ſcattered. This happens chiefly when the reapers, not being yet ſufficiently accuſtomed to that kind of ſcythe, do not know how to adapt it to particular circumſtances.

To remedy this inconvenience, it occurred to an ingenious blackſmith to add to the common ſcythe a *gatherer* or *collector* made of cloth, as may be ſeen at fig. 2. where *a b c* is a common ſcythe; *c d m l o f n e* is the gatherer; which at *c d e* is compoſed of a thin plate of iron, having at its extremity a hollow for receiving the point of the blade. At *e d* are holes for ſewing in the cloth, which is coarſe, light, and of low price; it is alſo fixed to two thick iron wires, of which the upper one is continued to *f*, where it terminates in a hole in the handle; the other is fixed to the back of the blade. The manner of fixing this gatherer to the blade of the ſcythe will be better underſtood by referring to fig. 3. which repreſents one of the irons which, by means of a ſcrew, are faſtened to the back of the ſcythe. Theſe irons proceed from, and make part of, the upright irons *m n*, *l o*, which ſerve to keep the gatherer extended.

This is a very ſimple and cheap contrivance; but an attempt was made to render it ſtill more ſimple, by ſubſtituting for the gatherer two iron hoops, which are ſhown in fig. 2. by the dotted lines *b g*, *k i*, with a croſs piece *p* which connects them. Experience, however, has ſhewn, that the gatherer is in general preferable to theſe hoops, as it does not leave an ear of corn behind.

RECTIFICATION of ether, a proceſs for depriving ether of its ſulphureous acid (See Chemistry, *Index* in this *Suppl.*) It has been uſual to add an alkali for this purpoſe; but Dizé has found it much more advantageous to add a ſubſtance which might afford the requiſite quantity of oxygen to convert the ſulphureous into the ſulphuric acid; in which ſtate it is not diſpoſed to riſe and come over. Various metallic oxyds were tried, among which the black oxyd of manganeſe proved the beſt and the cheapeſt. His proceſs is as follows:

The ſulphureous acid contained in unrectified ether being neutralized with oxyd of manganeſe, the fluid is decanted into a pewter veſſel of the capacity of fifty ounces, which is placed on a water bath. To this veſſel a head and worm are adapted, the latter of which paſſes through a refrigeratory conſtantly ſupplied with water in a ſtream from below, which cauſes the heated water to flow off above. The diſtillation is then performed by raiſing the bath to a temperature of 36° (113° Fahrenheit, if the decimal thermometer be here meant). The rectification by this treatment uſually requires a day to complete it. The flavour of the ether is of the beſt kind, and the product about one-ſixth more than in the uſual method with retort and receiver. Dizé has practiſed this method with ſucceſs for three years.—*Journal de Phyſique, April*, 1798.

Rectification, in geometry, is the finding of a right line equal to a curve. The rectification of curves is a branch of the higher geometry, a branch in which the uſe of the inverſe method of fluxions is eſpecially uſeful.

Turkey-RED, *Levant-Red*, and *Adrianople-Red*, the names indifferently given to that beautiful red dye which diſtinguiſhes the cotton manufactured in the Ottoman empire, and at *Aſtracan* in the dominions of Ruſſia. We have two accounts of the proceſs of communicating this dye to the ſtuffs; one by Profeſſor Pallas as he ſaw it practiſed at Aſtracan; the other in the 92d number of the *Annales de Chimie* by Citizen Felix. As every thing relating to uſeful manufactures is of general importance, we ſhall give pretty copious extracts from both papers.

According to Dr Pallas, the dye-ſtuffs employed at Aſtracan are, madder, ſumach, gall-nuts, alum, an inferior kind of ſoda, and fiſh-oil. The proceſs of dyeing is as follows:

The roots of the madder, when freſh gathered, are placed above each other in a ſtove, or in a pit dug in viſcous earth which has been ſtrongly heated. Earth is then thrown over the madder, and it muſt ſweat until the ſtove or pit becomes cold; when the roots, the ſecond or third day, are taken from it, and either ſpread out or hung up to dry. When it is thoroughly dried in the ſun, the madder is ground to a very fine powder, as are likewiſe the round leaves of the ſumach (*rhus cotinus*). The fiſh-oil is boiled from the entrails of the ſturgeon and other large fiſhes; and the proof of its being proper for dyeing is, that when mixed with a lixivium of ſoda, it muſt immediately aſſume a milky appearance. Should that not be the caſe, it cannot be uſed by the dyers.

The cotton to be dyed red is firſt waſhed exceedingly clean in running water; and when the weather is clear, hung up on poles to dry. If it does not dry before the evening, it is taken into the houſe, on account of

Turkey-Red.

of the ſaline dews ſo remarkable in the country around Aſtracan, and again expoſed to the air next morning. When it is thoroughly dry it is laid in a tub, and fiſh-oil is poured over it till it is entirely covered. In this ſtate it muſt ſtand all night; but in the morning it is hung up on poles, and left there the whole day; and this proceſs is repeated for a week, ſo that the cotton lies ſeven nights in oil, and is expoſed ſeven days to the atmoſphere, that it may imbibe the oil, and free itſelf from all air. The yarn is then again carried to a ſtream, cleaned as much as poſſible, and hung up on poles to dry.

After this preparation a mordant is made of three materials, which muſt give the grounds of the red colour. The pulveriſed leaves of the ſumach are firſt boiled in copper kettles; and when their colouring matter has been ſufficiently extracted, ſome powdered galls are added, with which the liquor muſt be again boiled; and by theſe means it acquires a dark dirty colour. After it has been ſufficiently boiled the fire is taken from under the kettle, and alum put into the ſtill hot liquor, where it is ſoon diſſolved. The proportion of theſe three ingredients cannot be aſcertained, as the dyers vary that proportion at pleaſure. The powder of the ſumach leaves is meaſured into the kettle with ladles; the water is poured in according to a gauge, on which marks are made to ſhew how high the water muſt ſtand in the kettle to ſoak ſix, eight, ten, &c. puds of cotton yarn. The galls and alum are added in the quantity of five pounds to each pud of cotton. In a word, the whole mordant muſt be ſufficiently yellow, ſtrong, and of an aſtringent taſte.

As ſoon as the alum is diſſolved, no time muſt be loſt in order that the mordant may not be ſuffered to cool. The yarn is then put into hollow blocks of wood ſhaped like a mortar, into each of which ſuch a quantity of the mordant has been poured as may be ſufficient to moiſten the yarn without any of it being left. As ſoon as the workman throws the mordant into the mortar, he puts a quantity of the yarn into it, and preſſes it down with his hand till it becomes uniformly moiſtened, and the whole cotton yarn has ſtruck. By this it acquires only a pale yellow colour, which, however, is durable. It is then hung up on poles in the ſun to dry; again waſhed in the ſtream, and afterwards dried once more.

The next part of the proceſs is to prepare the madder dye. The madder, ground to a fine powder, is ſpread out in large troughs, and into each trough is poured a large cupful of ſheep's blood, which is the kind that can be procured with the greateſt facility by the dyers. The madder muſt be ſtrongly mixed in it by means of the hand, and then ſtand ſome hours in order to be thoroughly ſoaked by it. The liquor then aſſumes a dark red appearance, and the madder in boiling yields more dye.

After this proceſs water is made hot in large kettles, fixed in brickwork; and as ſoon as it is warm, the prepared red dye is put into it, in the proportion of a pound to every pound of cotton. The dye is then ſuffered to boil ſtrongly; and when it is enough, which may be tried on cotton threads, the fire is removed from under the kettle, and the prepared cotton is depoſited near it. The dyer places himſelf on the edge of the brickwork that incloſes the kettle; dips the cotton yarn, piece by piece, into the dye; turns it round backwards and forwards; preſſes it a little with his hands; and lays each piece, one after the other, in pails ſtanding ready for the purpoſe. As ſoon as all the cotton has received the firſt tint, it is hung up to dry; as the red, however, is ſtill too dull, the yarn, which has been already dyed once, and become dry, is put once more into the dyeing-kettle, and muſt be left there to ſeethe for three hours over a ſtrong fire; by which it acquires that beautiful dark red colour which is ſo much eſteemed in the Turkey yarn. The yarn is now taken from the dye with ſticks; the ſuperfluous dye which adheres to it is ſhaken off; the hanks are put in order, and hung up, one after another, to dry. When it is thoroughly dry, it is waſhed in the pure ſtream, and again dried.

In the laſt place, the above-mentioned ſoda is diſſolved with boiling water in tubs deſtined for that purpoſe, and it is uſual at Aſtracan to allow 20 pounds of ſoda to 40 pounds of cotton, or half the weight. Large earthen jars, which are made in Perſia of very ſtrong clay, a yard and a half in height, almoſt five ſpans wide in the belly, and ending in a neck a ſpan and a half in diameter, incloſed by means of cement in brickwork over a fire-place, in ſuch a manner that the necks only appear, are filled with the dyed cotton yarn. The ley of diſſolved ſoda, which is blackiſh and very ſharp, is then poured over it till the jars be filled; and ſome clean rags are preſſed into their mouths, that the uppermoſt ſkains of yarn may not lie uncovered. A fire is then made in the fire place below, and continued for 24 hours; and in the mean time the ſteam which ariſes from the jars is ſeen collected among the rags in red drops. By this boiling the dye is ſtill more heightened, and is made to ſtrike completely; every thing ſuperfluous is removed, and all the fat matter which ſtill adheres to the yarn is waſhed out. Nothing more is then neceſſary for completing the dye of the yarn but to rinſe it well ſeveral times in running water, and then to dry it.

Cotton cloth is dyed with madder at Aſtracan in the ſame manner; but many purſue a fraudulent proceſs, by dyeing with red wood, and then ſell their cloth as that which has been dyed in the proper manner.

The proceſſes followed in the Grecian manufactories in the Levant, as deſcribed by M. Felix, varies in ſome particulars from this. The firſt proceſs is that of cleaning the cotton: for which purpoſe three leys are employed; one of ſoda, another of aſhes, and a third of lime. The cotton is thrown into a tub, and moiſtened with the liquor of the three leys in equal quantities: it is then boiled in pure water, and waſhed in running water.

The ſecond bath given to the cotton is compoſed of ſoda and ſheep's dung diſſolved in water. To facilitate the ſolution, the ſoda and dung are pounded in a mortar. The proportions of theſe ingredients employed, are one occa of dung, ſix of ſoda, and forty of water; each occa being equal to about fifty ounces. When the ingredients are well mixed, the liquor expreſſed from them is ſtrained; and being poured into a tub, ſix occas of olive oil are added to it, and the whole is well ſtirred till it becomes of a whitiſh colour like milk. The cotton is then beſprinkled with this water; and when the ſkains are thoroughly moiſtened, they are wrung, preſſed, and expoſed to dry. The ſame bath muſt be repeated three or four times, becauſe it is this liquor which renders the cotton more or leſs fit for receiving the dye. Each bath is given with the ſame liquor, and ought to continue five or ſix hours. It is to be obſerved that the cotton, after each bath, muſt be dried without being waſhed, as it ought not to be rinſed till after the laſt bath. The cotton is then as white as if it had been bleached in the fields.

It may be ſuppoſed that the dung is of no utility for fixing the colours: but this ſuppoſition would be raſh; for, as M. Felix obſerves, it is well known that this ſubſtance contains a great quantity of volatile alkali in a diſengaged ſtate, which has the property of giving a roſy hue to the red. It is therefore probable that it is to this ingredient that the red dyes of the Levant are indebted for their ſplendour and vivacity. This much, at any rate, is certain, that the Morocco leather of the Levant is prepared with dog's dung; becauſe it has been found that this dung is proper for heightening the colour of the lack.

The proceſs of galling, which follows the bath of dung, is performed by immerſing the cotton in a bath of warm water, in which five occas of pulveriſed gall-nuts have been boiled. This operation renders the cotton more fit for being ſaturated with the colour, and gives to the dye more body and ſtrength. After the galling comes aluming, which is performed twice, with an interval of two days, and which conſiſts in dipping the cotton into a bath of water in which five occas of alum have been infuſed, mixed with five occas of water alkaliſed by a ley of ſoda. The aluming muſt be performed with care, as it is this operation which makes the colouring particles combine beſt with the cotton, and which ſecures them in part from the deſtructive action of the air. When the ſecond aluming is finiſhed, the cotton is wrung; it is then preſſed, and put to ſoak in running water, after being incloſed in a bag of thin cloth.

The workmen then proceed to the dyeing. To compoſe the colours, they put in a kettle five occas of water, and 35 occas of a root which the Greeks call *ali-zari*, or painting colour, and which in Europe is known under the name of *madder*. The madder, after being pulveriſed, is moiſtened with one occa of ox or ſheep's blood. The blood ſtrengthens the colour, and the doſe is increaſed or leſſened according to the ſhade of colour required. An equal heat is maintained below the kettle, but not too violent; and when the liquor ferments, and begins to grow warm, the ſkains are then gradually immerſed before the liquor becomes too hot. They are then tied with packthread to ſmall rods placed croſſwiſe above the kettle for that purpoſe; and when the liquor boils well, and in an uniform manner, the rods from which the ſkains were ſuſpended are removed, and the cotton is ſuffered to fall into the kettle, where it muſt remain till two-thirds of the water is evaporated. When one third only of the liquor remains, the cotton is taken out and waſhed in pure water.

The dye is afterwards brought to perfection by means of a bath alkaliſed with ſoda. This manipulation is the moſt difficult and the moſt delicate of the whole, becauſe it is that which gives the colour its tone. The cotton is thrown into this new bath, and made to boil over a ſteady fire till the colour aſſumes the required tint. The whole art conſiſts in catching the proper degree: a careful workman, therefore, muſt watch with the utmoſt attention for the moment when it is neceſſary to take out the cotton; and he will rather burn his hand than miſs that opportunity.

It appears that this bath, which the Greeks think of ſo much importance, might be ſupplied by a ley of ſoap; and it is probable that ſaponaceous water would give the colour more brightneſs and purity.

M. Felix ſeems doubtful whether the ali-zari of the Greeks be the ſame plant with the European madder. If it be, its ſuperiority muſt ariſe from the mode in which it is cultivated, and the method employed to dry it. The ali-zari is not collected till the fifth or ſixth year of its growth, when it has acquired its full ſtrength; and as it is the woody part of the roots which affords the greateſt quantity of colouring particles, this muſt give it an obvious ſuperiority over madder, which is collected before it has arrived at maturity. The mode of deſiccation contributes alſo, in the opinion of our author, to improve the quality of the ali-zari. The Levantines dry it in the open air; and this operation is eaſy in a country where great dryneſs prevails in the atmoſphere, while in our damp climates we are obliged to dry the madder by ſtoves. Hence it happens that the ſmoke, which mixes itſelf with the cold air, and penetrates the roots, impregnates them with fuliginous particles, which alter the colouring ſubſtance; an accident which does not take place when the madder is dried without the aſſiſtance of fire.

For the philoſophical principles of theſe proceſſes of dyeing, ſee *Animal and Vegetable Subſtances* in this *Supplement*.

REDINTEGRATION, is the taking or finding the integral or fluent again from the fluxion. See Fluxions, *Encycl.*

REFLECTOR for a light-house, is compoſed of a number of ſquare plane glaſs mirrors, ſimilar to thoſe with which Archimedes is ſaid to have ſet fire to the Roman fleet at the ſiege of Syracuſe (See Burning, *Encycl.*) Each of theſe mirrors is about an inch ſquare; and they are all diſpoſed cloſe to each other in the concave of a parabolic ſegment, formed of ſtucco or any other proper bed. Stucco has been found to anſwer the purpoſe beſt; and is accordingly employed in all the reflectors of the light-houſes erected by Mr Thomas Smith tinplate worker, Edinburgh, at the expence, and by the authority, of government. This ingenious and modeſt man ſeems to have conceived the idea of illuminating light-houſes by means of lamps and reflectors inſtead of coal-fires, without knowing that ſomething of the ſame kind had been long uſed in France; he has therefore all the merit of an inventor, and what he invented he has carried to a high degree of perfection.

His parabolic moulds are from three to five or ſix feet in diameter; and in the centre or apex of each is placed a long ſhallow lamp of tin-plate, filled with whale oil. In each lamp are ſix cotton wicks, almoſt contiguous to each other, which are ſo diſpoſed as to burn without trimming for about ſix hours. The light of theſe is reflected from each mirror ſpread over the concave ſurface, and is thus multiplied, as it were, by the number of mirrors. The ſtucco moulding is covered on the back with tin-plate, from which a tube, immediately over the lamp, proceeds to the roof of the

Reflector, Reflexity.

light room, and ſerves as a funnel, through which the ſmoke eſcapes without ſullying the faces of the mirrors. The light-room is a cupola or lantern of from eight to twelve ſides, compoſed entirely of glaſs, fixed in caſt-iron frames or ſaſhes, and roofed with copper. On circular benches paſſing round the inſide of this lantern, at about eighteen inches from the glaſs frames, are placed the reflectors with their lamps, ſo as that the concave ſurfaces of two or three of the reflectors front every point of the compaſs, and throw a blaze of light in all directions. In the roof immediately over the centre of the room is a hole, through which paſs all the funnels already mentioned, and which ſerves likewiſe to admit freſh air to the lamps. This light-room is firmly fixed on the top of a round tower ſo as to be immoveable by the weather; and the number of the reflectors, and the height of the tower, are leſs or greater according as it is the intention that the light ſhould be ſeen at a leſs or a greater diſtance.

A man judging from mere theory would be very apt to condemn light-houſes of this kind; becauſe the firmeſt building ſhakes in a violent ſtorm, and becauſe ſuch ſhaking, he might think, would ſometimes throw the whole rays of light into the air, and thus miſlead the bewildered ſeaman. This opinion, we know, was actually entertained of them by one of the profoundeſt philoſophers and moſt ſcientific mechanicians of the age. Experience, however, has convinced him, as well as the public at large, that ſuch apprehenſions are groundleſs, and that light-houſes with lamps and reflectors are, in every point of view, preferable to thoſe with fires burning in the open air. They are ſupported at much leſs expence; their light is more brilliant, and ſeen at a greater diſtance, whilſt it can never be obſcured by ſmoke, or beaten down on the lee-ſide by a violent guſt of wind; and what is perhaps of ſtill greater importance, the reflectors with their lamps may be ſo variouſly placed, that, as Mr Smith obſerves, one light-houſe cannot be miſtaken for another. If we add to all this, that the lamps do not ſtand in need of trimming ſo often as open fires require fuel, and that the light man is never expoſed either to cold or to wet by attending to his duty, we muſt be convinced that light-houſes with reflectors are much leſs liable to be neglected in ſtormy weather than thoſe with open fires, and that this circumſtance alone would be enough to give the former a preference, almoſt incalculable, over the latter.

It has been propoſed to make the concave ſurface of the parabola one ſpeculum of metal, inſtead of covering it over with a multitude of plain glaſs mirrors; or to diminiſh the ſize of each mirror, if they are to be retained in preference to the metallic ſpeculum. To every man who has but dipped into the ſcience of optics, it muſt be obvious, that either of theſe alterations would be wrong. The brighteſt metal does not reflect ſuch a quantity of light as well foliated clear glaſs; and were the ſize of the mirrors to be diminiſhed, the number of joinings would be increaſed, in each of which ſome light is loſt, not merely in the ſeam, but from its being almoſt impoſſible to foliate glaſs perfectly at its edge.

REFLEXITY, a word employed by Mr Brougham to denote a property of light which cauſes the different rays to be acted upon by bodies, and to begin to be refracted, reflected, inflected, and deflected, at different diſtances. This property follows the ſame law that the other optical properties of light follow: the red ray having moſt reflexity, and the violet leaſt (See *Philoſophical Tranſactions*, 1797, p. 360.) Mr Brougham has denoted this property by the three words, *refrangity*, *reflexity*, and *flexity*; but as the power is the ſame, there is no occaſion for different names. Some philoſophers have refuſed to admit this as a new property; we have not verified it by experiment.

Refraction.

REFRACTION OF ALTITUDE, is the arc or portion of a vertical circle, by which the altitude of a ſtar is increaſed by the refraction of light.

REFRACTION *of Aſcenſion and Deſcenſion*, is an arc of the equator, by which the aſcenſion and deſcenſion of a ſtar, whether right or oblique, is increaſed or diminiſhed by the refraction.

REFRACTION *of Declination*, is an arc of a circle of declination, by which the declination of a ſtar is increaſed or diminiſhed by refraction.

REFRACTION *of Latitude*, is an arc of a circle of latitude, by which the latitude of a ſtar is increaſed or diminiſhed by the refraction.

REFRACTION *of Longitude*, is an arc of the ecliptic, by which the longitude of a ſtar is increaſed or diminiſhed by means of the refraction.

Terreſtrial REFRACTION, is that by which terreſtrial objects appear to be raiſed higher than they really are, in obſerving their altitudes. The quantity of this refraction is eſtimated by Dr Maſkelyne at one tenth; by Le Gendre at one-fourteenth; by De Lambre at one-eleventh; and by others at a twelfth of the diſtance of the object obſerved, expreſſed in degrees of a great circle. But it is obvious that there can be no fixed quantity of this refraction, ſince it depends upon the ſtate of the atmoſphere, which is extremely variable. Hence ſome very ſingular effects of it are related, of which the following is worthy of notice. It is taken from the Philoſophical Tranſactions of London 1798; being an extract of a letter, dated Haſtings, Auguſt 1. 1797.

“On Wedneſday, July 26, about five o'clock in the afternoon. while I was ſitting in my dining room at this place, which is ſituated upon the Parade, cloſe to the ſea ſhore, nearly fronting the ſouth, my attention was excited by a number of people running down to the ſea-ſide. Upon enquiring the reaſon, I was informed that the coaſt of France was plainly to be diſtinguiſhed by the naked eye. I immediately went down to the ſhore, and was ſurpriſed to find that, even without the aſſiſtance of a teleſcope, I could very plainly ſee the cliffs on the oppoſite coaſt; which, at the neareſt part, are between 40 and 50 miles diſtant, and are not to be diſcerned, from that low ſituation, by the aid of the beſt glaſſes. They appeared to be only a few miles off, and ſeemed to extend for ſome leagues along the coaſt. I purſued my walk along the ſhore eaſtward, cloſe to the water's edge, converſing with the ſailors and fiſhermen upon the ſubject. They at firſt could not be perſuaded of the reality of the appearance; but they ſoon became ſo thoroughly convinced, by the cliffs gradually appearing more elevated, and approaching nearer, as it were, that they pointed out and named to me the different places they had been accuſtomed to viſit; ſuch as the Bay, the Old Head or Man, the Windmill, &c. at Boulogne; St Vallery, and other places on the coaſt of Picardy; which they aftewards confirmed when they viewed them through their teleſcopes. Their obſervations were, that the places appeared as near as if they were ſailing, at a ſmall diſtance, into the harbours."

The writer of this extract was W. Latham, Eſq; F R. S. and A. S. who adds, that the day was extremely hot, that it was high water at Haſtings about two o'clock P. M. and that not a breath of wind was ſtirring the whole day.

REGIS (Peter Sylvain), a French philoſopher, and great propagator of Carteſianiſm, was born in Agenois 1632. He cultivated the languages and philoſophy under the Jeſuits at Cahors, and afterwards divinity in the univerſity of that town, being deſigned for the church. He made ſo uncommon a progreſs, that at the end of four years he was offered a doctor's degree without the uſual charges; but he did not think it became him to accept of it till he had ſtudied alſo in the Sorbonne at Paris. He went thither, but was ſoon diſguſted with theology; and as the philoſophy of Des Cartes began at that time to make a noiſe through the lectures of Rohault, he conceived a taſte for it, and gave himſelf up entirely to it. He frequented theſe lectures; and becoming an adept, went to Toulouſe in 1665, and read lectures in it himſelf. Having fine parts, a clear and fluent manner, and a happy way of making himſelf underſtood, he drew all ſorts of people; the magiſtrates, the learned, the eccleſiaſtics, and the very women, who now all affected to abjure the ancient philoſophy. In 1680 he returned to Paris; where the concourſe about him was ſuch, that the ſticklers for Peripateticiſm began to be alarmed. They applied to the archbiſhop of Paris, who thought it expedient, in the name of the king, to put a ſtop to the lectures; which accordingly were diſcontinued for ſeveral months. The whole life of Regis was ſpent in propagating the new philoſophy. In 1690 he publiſhed a formal ſyſtem of it, containing logic, metaphyſics, phyſics, and morals, in 3 vols 4to, and written in French. It was reprinted the year after at Amſterdam, with the addition of a diſcourſe upon ancient and modern philoſophy. He wrote afterwards ſeveral pieces in defence of his ſyſtem; in which he had diſputes with M. Huet, Du Hamel, Malebranche, and others. His works, though abounding with ingenuity and learning, have been diſregarded, in conſequence of the great diſcoveries and advancement in philoſophic knowledge that have been ſince made. He died in 1707. He had been choſen member of the academy of ſciences in 1699*.

REGULAR BODY, called alſo *Platonic Body*, is a body or ſolid comprehended by like, equal, and regular plane figures, and whoſe ſolid angles are all equal.

The plane figures by which the ſolid is contained are the faces of the ſolid; and the ſides of the plane figures are the edges, or linear ſides of the ſolid.

There are only five regular ſolids, viz.

The tetrahedron, or regular triangular pyramid, having four triangular faces;
The hexahedron, or cube, having ſix ſquare faces;
The octahedron, having eight triangular faces;
The dodecahedron, having twelve pentagonal faces;
The icoſahedron, having twenty triangular faces.

Beſides theſe five, there can be no other regular bodies in nature. See PLATONIC *Body*, Suppl.

REGULUS, in aſtronomy, a ſtar of the firſt magnitude, in the conſtellation Leo; called alſo, from its ſituation, *Cor Leonis*, or the *Lion's Heart*; by the Arabs, *Alhabor*; and by the Chaldeans, *Kalbeleced*, or *Karbeleceid*; from an opinion of its influencing the affairs of the heavens.

REID (Thomas, D. D.), ſo well known to the public by his moral and metaphyſical writings, was the ſon of the Rev. Lewis Reid, miniſter of the pariſh of Strachan, in the county of Kincardine, North Britain. His mother was the daughter of David Gregory, Eſq; of Kinardie, of whom ſome account has been given in this *Supplement*, and ſiſter to David, James, and Charles Gregories, who were at the ſame time profeſſors of aſtronomy, or mathematics, in the univerſities of Oxford, Edinburgh, and St Andrews.

He was born at the parſonage-houſe of Strachan in April 1710, and received the rudiments of his education at the pariſh ſchool of Kincardine-oniel. At that period the parochial ſchools of Scotland were very ſuperior to what they are now; and young men went from them to the univerſity well furniſhed with philological learning. The progreſs of young Reid muſt have been rapid; for he was removed from ſchool to the Mariſchal College, Aberdeen, when not more than twelve years of age; and we have never heard that he was admitted into the univerſity before he was qualified to profit by the lectures of the profeſſors. On the contrary, he ſoon diſplayed the genius of his mother's family, and ſhone conſpicuous among the ſtudents of mathematics in a college where that ſcience has been at all times cultivated with ardour and ſucceſs.

After the uſual courſe of four years employed in the ſtudy of Latin, Greek, Mathematics, and Philoſophy, he probably took his degree of M. A. which at that period, and for a long time ſubſequent to it, was the univerſal practice in the univerſity of Aberdeen, and then commenced the ſtudy of theology. In due time he was licenſed to preach the goſpel according to the forms of the church of Scotland; but continued to reſide for ſome years in Aberdeen, cultivating his favourite ſcience, mathematics.

The mathematical chair in Mariſchal College was then filled by Mr John Stuart, a man of great eminence in his profeſſion; but who, like many other profound mathematicians, was not happy in his mode of communicating ſcience, at leaſt to the duller part of his pupils. Mr Reid occaſionally read lectures for the profeſſor; and a friend of our's, by no means dull, has often been heard to expreſs great ſatisfaction that Mr Stuart was kept a whole winter from the ſchools, when he was a ſtudent, and that the claſs was taught by Mr Reid. "Had it not been for this circumſtance (ſaid he) I ſhould never have underſtood more of mathematics than the firſt ſix books of Euclid's elements; but Mr Reid had the faculty of making every thing intelligible to the ſtudents which he clearly apprehended himſelf."

He could not, however, ſpend his life in the ſtudy of mathematics, and in reading barren lectures for other men. He had been educated for the church; and it was in the church only that he had the proſpect of gaining a livelihood. He was accordingly preſented, we know not in what year, to the church of *New Machar* in Aberdeenſhire, at a time when the good people of Scotland were very far from being reconciled to the rights of patronage; and the conſequence was,

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* *Biog. Dict.* new edit.

that his ſettlement met with much popular oppoſition. Even a little riot took place in the church at his ordination; but he ſoon gained the affections of his flock by his good ſenſe, his acknowledged worth, and his unwearied attention to all their wants, which he was ever ready to relieve to the utmoſt extent of his abilities. So deeply rooted indeed was their regard for him at laſt, that, though it is now almoſt half a century ſince his relation to the pariſh of New Machar ceaſed, his memory continues to be revered in that pariſh even at the preſent day; and the following anecdote evinces that it is not revered without reaſon.

A man who, from being in decent circumſtances, and a member of the kirk ſeſſion (See PRESBYTERIANS, *Encycl.*), when Dr Reid was miniſter, had become, in his old age, poor and infirm, obſerved to the then miniſter of the pariſh, that if he were able to go to Glaſgow, and make his caſe known to his old friend and paſtor, he was ſure that he would get ſomething done for him. This obſervation was reported to the Doctor, who inſtantly recollected the man, though, in all probability, he had not thought of him for thirty years; and he ſettled upon him an annual penſion of ten pounds, which was punctually paid as long as they both lived. The pride of ſcience had not from the mind of this great man eradicated the amiable ſympathies of humanity, nor had his philoſophic fame made him overlook the unaſpiring duties of the Chriſtian paſtor.

In the year 1751, about the beginning of the ſeſſion or annual term, one of the profeſſors of philoſophy in King's College, Aberdeen, died; and his death being unexpected, preſented to the other members of that learned body ſome difficulty in carrying on the uſual courſe of education for that year. At this our readers will not be ſurpriſed, when they reflect on the mode in which ſcience was taught in that univerſity; for he who could with propriety be placed in the vacant chair, muſt have been qualified, without much previous preparation, to read lectures on LOGIC, ONTOLOGY, PNEUMATICS, MORALS, POLITICS, MATHEMATICS, and NATURAL PHILOSOPHY (See GERARD, in this *Suppl.*). In ſuch a place as Aberdeen, it is hardly to be ſuppoſed that there was a ſingle man unemployed, ſo completely maſter of all theſe branches of ſcience, as to take up the claſs where it was dropt by the deceaſed profeſſor, and carry it ſucceſsfully through that ſcience, whatever it might be, in which, at his death, he chanced to be lecturing. It occurred, however, to the principal, and ſome of the profeſſors, that the miniſter of New Machar was fully equal to the taſk; and the late Dr John Gregory, then profeſſor of medicine, and the Rev. Dr Macleod, the preſent ſubprincipal of King's College, were deputed to viſit Mr Reid, and requeſt his immediate acceptance of the vacant profeſſorſhip. He yielded to the requeſt not without ſome heſitation, and was admitted profeſſor of philoſophy on the 22d of November.

He was now in the very ſituation for which Nature ſeemed to have intended him. He had not only an opportunity, but it was his duty to cultivate the ſcience to which his attachment was ſo ſtrong; and the duties of his office made him turn his attention more cloſely than he had hitherto done to another ſcience, in which he was deſtined to make a more conſpicuous figure than he ever made even in his favourite mathematics.

It was during his profeſſorſhip in the univerſity of Aberdeen that he wrote his "Eſſay on Quantity," which was publiſhed in the 45th volume of the Philoſophical Tranſactions, and is perhaps the fineſt ſpecimen of metaphyſical mathematics, if we may uſe ſuch an expreſſion, that is extant in our own or in any other language (See QUANTITY, *Encycl.*). It was during the ſame period that he publiſhed his "Inquiry into the Human Mind on the Principles of Common Senſe;" a work of unqueſtionable merit, which has contributed more than any other work whatever to give a rational turn to metaphyſical ſpeculations. It was about this period that the degree of D. D. was conferred upon him by his mother college.

The well earned fame of Dr Reid attracted the attention of the univerſity of Glaſgow to him as the fitteſt perſon to ſucceed the celebrated Dr Adam Smith; and he was admitted profeſſor of moral philoſophy in that univerſity on the 11th of June 1764. There his attention was not diſtracted by a multitude of ſciences, which it was his duty to teach; and he had leiſure to improve his metaphyſical ſyſtem, though he continued through life to amuſe himſelf occaſionally with mathematical ſpeculations.

In the year 1773 appeared, in Lord Kames's "Sketches of the Hiſtory of Man, a brief Account of Ariſtotle's Logic; with remarks by Dr Reid." It would ſeem that he had entered upon this taſk rather reluctantly, and merely in compliance with the ſolicitations of his friend, the author of the Sketches. "In attempting (ſays he) to give ſome account of the analytics, and of the topics of Ariſtotle, ingenuity requires me to confeſs, that though I have often purpoſed to read the whole with care, and to underſtand what is intelligible, yet my courage and patience always failed before I had done. Why ſhould I throw away ſo much time and painful attention upon a thing of ſo little uſe? If I had lived in thoſe ages when the knowledge of Ariſtotle's Organon intitled a man to the higheſt rank in philoſophy, ambition might have induced me to employ upon it ſome years of painful ſtudy; and leſs, I conceive, would not be ſufficient. Such reflections as theſe always got the better of my reſolution, when the firſt ardour began to cool. All I can ſay is, that I have read ſome parts of the different books with care, ſome ſlightly, and ſome perhaps not at all. I have glanced over the whole often; and when any thing attracted my attention, have dipped into it till my appetite was ſatisfied."

Notwithſtanding this modeſt acknowledgment, we are not ſure that any one of Dr Reid's publications does him greater honour than his very perſpicuous view of this ſtupendous ſyſtem. Having ourſelves occaſionally looked into the writings of Ariſtotle, we ſhould not heſitate to ſay, that it is by much the beſt analyſis of theſe writings that we have anywhere met with, even though we could not corroborate our own opinion by that of other men much more converſant than we are with the oracular language of the Stagyrite. But when it is known that the late Dr Doig of Stirling, to whom Greek was as familiar as his mother tongue, and an equally learned Doctor of Oxford, who has been reading Ariſtotle ever ſince he was fourteen years of age, agreed in opinion, that a more accurate view of his logic could not be given in the ſame compaſs than had been given by Dr Reid, we may ſurely affirm, with ſome degree of confidence, that this ſmall work adds much to the fame of our celebrated countryman.

Though Dr Reid's health continued good, and his mental faculties unimpaired, till a very ſhort time before his death, he ceaſed for ſome years to read lectures from his profeſſorial chair, employing that time in preparations for eternity, and in fitting his lectures for the preſs. Theſe were publiſhed in two volumes 4to: the the firſt in 1785, under the title of "Eſſays on the Intellectual Powers of Man," dedicated to his friends Dr Gregory and Profeſſor Stewart, both of the univerſity of Edinburgh; and the ſecond in 1788, under the title of "Eſſays on the Active Powers of Man," without any dedication or preface. He continued to enjoy the fame acquired by this work, as well as the affection of his friends and the reverence of the public, for eight years, dying at Glaſgow in the end of September, or the beginning of October 1796, in the 87th year of his age. He had been married, and he left behind him one daughter.

To do juſtice to the biography of ſuch a man as this, we ſhould here attempt to draw his intellectual character, and to appreciate the merits of his works; but to perform this taſk in a manner at all worthy of him, or we hope of ourſelves, would require more room than our limits permit us to allot to any article of the kind; and our readers will be pleaſed to learn, that they may confidently expect an account of his life, with a critique on his works, by a man better qualified to do juſtice to both, than the writer of this ſhort ſketch pretends to be. His works are in the hands of the ſpeculative public; and by that public will be duly valued, as long as ſound ſenſe ſhall be preferred to impious jargon. How long that may be, God only knows; but if any thing can guard the minds of our youth againſt that ſophiſtry of which the object is to attribute real agency to material fluids, and to repreſent the elective attractions of chemiſtry as perfectly ſimilar to human volitions, it will be the unbiaſſed ſtudy of Dr Reid's "Eſſays on the Intellectual and Active Powers of Man." They will there find metaphyſics diveſted of myſtery, and the profoundeſt ſpeculations rendered intelligible by the conſtant uſe of words in one determined ſenſe. We think, indeed, that in this conſiſts the Doctor's chief merit; for, except when treating of our notions of power, he ſeems not to have added much to what certainly *may be* found in the writings of Locke.

Let not our readers ſuppoſe, that by this obſervation we wiſh to detract in the ſmalleſt degree from our author's fame, or to leſſen him by compariſon with the Engliſh philoſopher. If on mere topics of ſpeculative ſcience, he appears to us to have thought as Locke thought, it is on the other hand certain, that the greater part of Locke's doctrines may be gleaned from the logical and metaphyſical writings of Bacon, Hobbes, and Des Cartes. Nor need this ſurpriſe any one; for he who reflects a moment on the ſubject, muſt perceive that ſuch a coincidence of thought in metaphyſical ſcience is among men of eminence almoſt inevitable. Of mind and its powers—the ſubject of that ſcience—we neither know, nor can know any thing, but by patiently attending to the operations of our own minds, when we ſee, hear, feel, think, reaſon, and will, &c.: and it is obvious, that every man who is capable of ſuch patient attention, and does not labour under the bias of ſome prejudice, muſt view theſe operations in the ſame way. The great ſuperiority of Dr Reid over his predeceſſors, in this department of ſcience, appears to have been this, that he apprehended the operations of his own mind with a clearneſs, which gave to his language a preciſion and perſpicuity which the language of Locke certainly does not poſſeſs

In the Eſſay on the Human Underſtanding, the term *idea* ſometimes ſignifies a material ſubſtance, ſometimes the qualities of that ſubſtance, ſometimes the conception of theſe qualities, ſometimes the power or faculty of the mind by which we conceive a thing, ſometimes a perception of ſenſe, and ſometimes an intellectual notion. Hence the ambiguity of terms which runs thro' the whole of that immortal work, has furniſhed both the author's friends and his enemies with an opportunity of attributing to him pernicious doctrines, which we are perſuaded he did not maintain, and which, we think, a patient analyſis of the eſſay muſt *convince every man* that he did not maintain. From this ambiguity the writings of Dr Reid are perfectly free. His doctrines, whether well or ill-founded, can never be miſunderſtood by him who is deſirous to underſtand them; and he who knows how much perſpicuity of ſtyle depends upon accuracy of thinking, will not deem us enemies to his fame for having ſaid that his chief merit conſiſts in the preciſion of his language.

He has been much cenſured by ſome, and much applauded by others, for introducing the phraſe *common ſenſe* into ſpeculative philoſophy, as the proper name of that faculty of the mind by which we apprehend firſt truths; but he is on this account entitled neither to praiſe nor to cenſure. He adopted the phraſe from others; and has proved, by the moſt unexceptionable authorities, both ancient and modern, that it may with great propriety be uſed as he has uſed it. Whether the adopting of it into works of ſcience was neceſſary, is another queſtion, on which we have given our opinion elſewhere; it is ſufficient in this place to vindicate his uſe of it, eſpecially in his latter works, from ambiguity.

Candour obliges us to acknowledge, that he has advanced ſome doctrines which we cannot admit as true. Though not in general partial to Locke, he has adopted his notions reſpecting our power of abſtraction, with hardly any other variation than the ſubſtituting of the term *conceptions* for Locke's favourite phraſe *ideas*. He has likewiſe endeavoured to prove, that we may diſtinctly conceive what cannot poſſibly exiſt. Theſe miſtakes, for ſuch they appear to us, we have pointed out elſewhere (See METAPHYSICS, Part I. Chap. iii. and iv. *Encycl.*); but they are infinitely more than counterbalanced by his clear, accurate, and ſatisfactory diſquiſitions on our notions of active power. Had Dr Reid never written a ſentence but the eſſay which treats of this delicate and important ſubject, he would have been entitled to a place in the very firſt rank of uſeful metaphyſicians; for, previous to the appearance of his works, we had nothing written directly on *power* but contradictory and unintelligible jargon. We recommend the ſerious peruſal of this eſſay, the firſt in his ſecond volume, to ſuch of our readers as fancy that they diſtinctly conceive the powers of chemical agents, and that intelligence and volition may reſult from any mechanical